

Corrosion

Official Publication

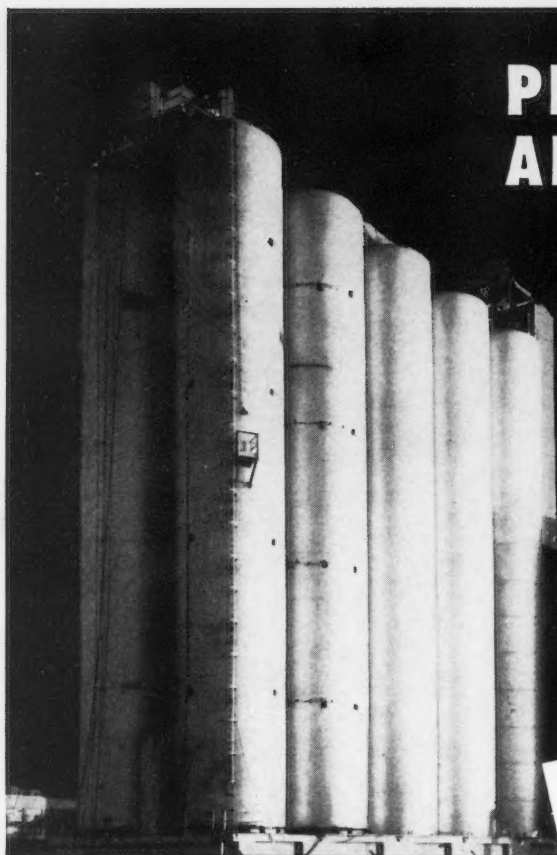
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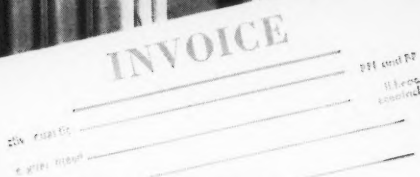
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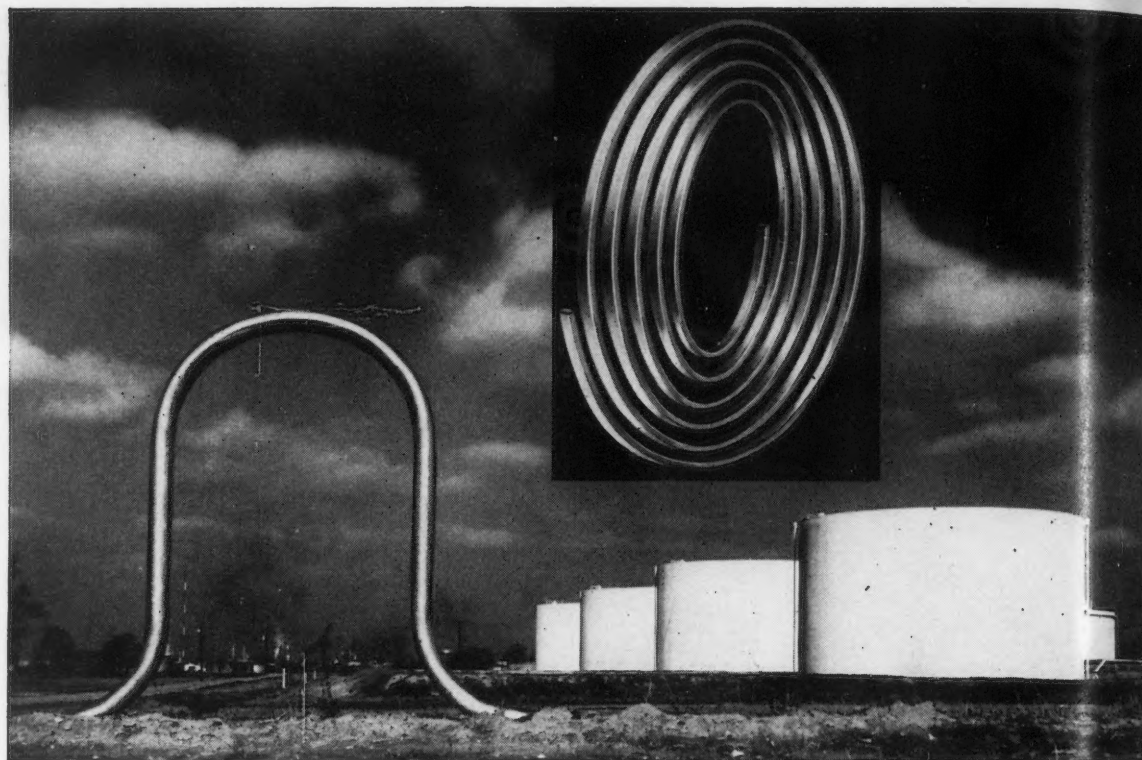
←This is one of warning designs adopted by the Chemical Industries Committee, International Labor Organization, for the labeling of corrosive substances that are shipped across national boundaries. ILO hurdled the language barrier by choosing labels without words so that illiterate workers in any country could be warned of danger.



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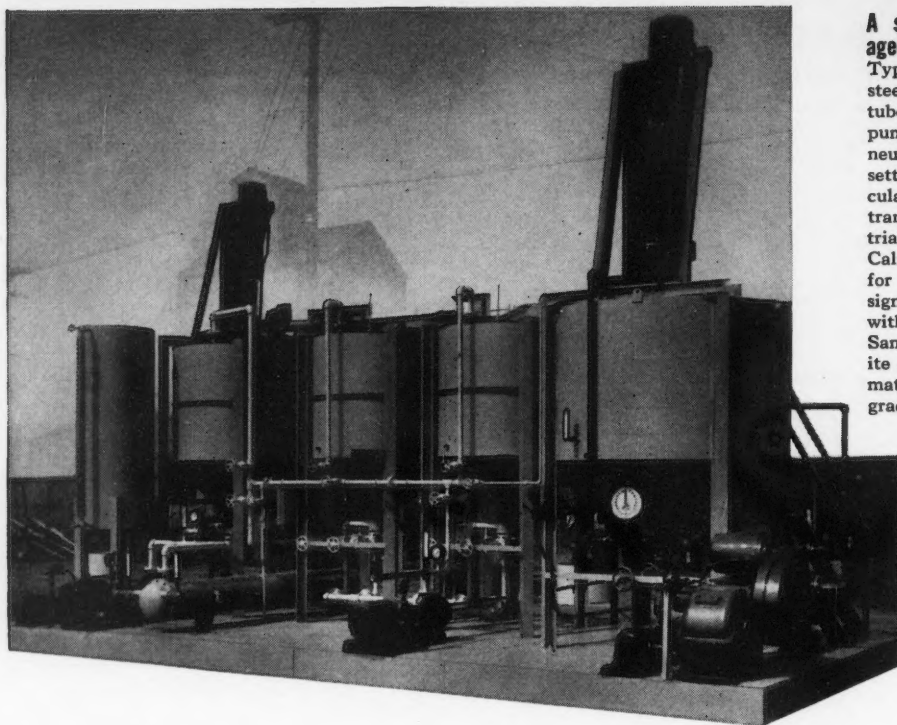
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NEWS REPORTS FOR CORROSION

News reports on activities of regions, sections and other subdivisions of the National Association of Corrosion Engineers should reach Central Office NACE before the tenth of the month preceding the month in which the report is to be published.

• Secretaries who do not already have a supply are invited to ask for copies of the form "News Report for Corrosion" which facilitates making reports on meetings. Notices of future meetings will be carried in the "NACE Calendar" in the News Section when information is provided in time.

• News of meetings of corrosion interest of whatever origin are welcomed and will be carried when space permits.



A standard prefabricated "packaged" detergent plant . . . utilizing Type 316 chromium-nickel stainless steel for heat exchanger shells and tubes, sulfonator tank, neutralizer pump, seats and valves, hold tanks, neutralizer tanks, settling tanks, settling tank pumps, agitators, circulating pump on sulfonator, and transfer pump on hold tanks. Industrial Engineers, Inc., of Los Angeles, Calif., a manufacturer of equipment for production of detergents, designed this unit in collaboration with the Oronite Chemical Co., of San Francisco, producers of "Oronite Alkane" . . . a widely used raw material for manufacture of high grade detergent products.

How New Prefabricated Detergent Plant Licks Corrosion

Designed to produce indefinitely under severest conditions, this standard prefabricated detergent plant relies on an alloy containing nickel for corrosion resistance and protection against product contamination.

Peak performance, with a minimum of maintenance, is obtained by utilizing equipment fabricated from Type 316 austenitic chromium-nickel stainless steel . . .

For Type 316 stainless resists attacks by the extremely corrosive media encountered.

Throughout the process industries, low-cost operations result from using austenitic chromium-nickel stainless steels to defeat corrosion and assure maximum equipment life per dollar invested.

Stainless steels often permit making equipment lighter in weight without sacrificing strength or safety. When cold-worked they are strengthened

and hardened, and a tensile strength in excess of 200,000 p.s.i. is easily developed. Annealed, and even in the cold-worked condition, they are adaptable to many forming operations. In all conditions they are readily weldable.

At elevated temperatures, austenitic chromium-nickel stainless steels are distinguished by their strength and outstanding resistance to oxidation. At temperatures down to -300°F . they retain their toughness and unusual strength.

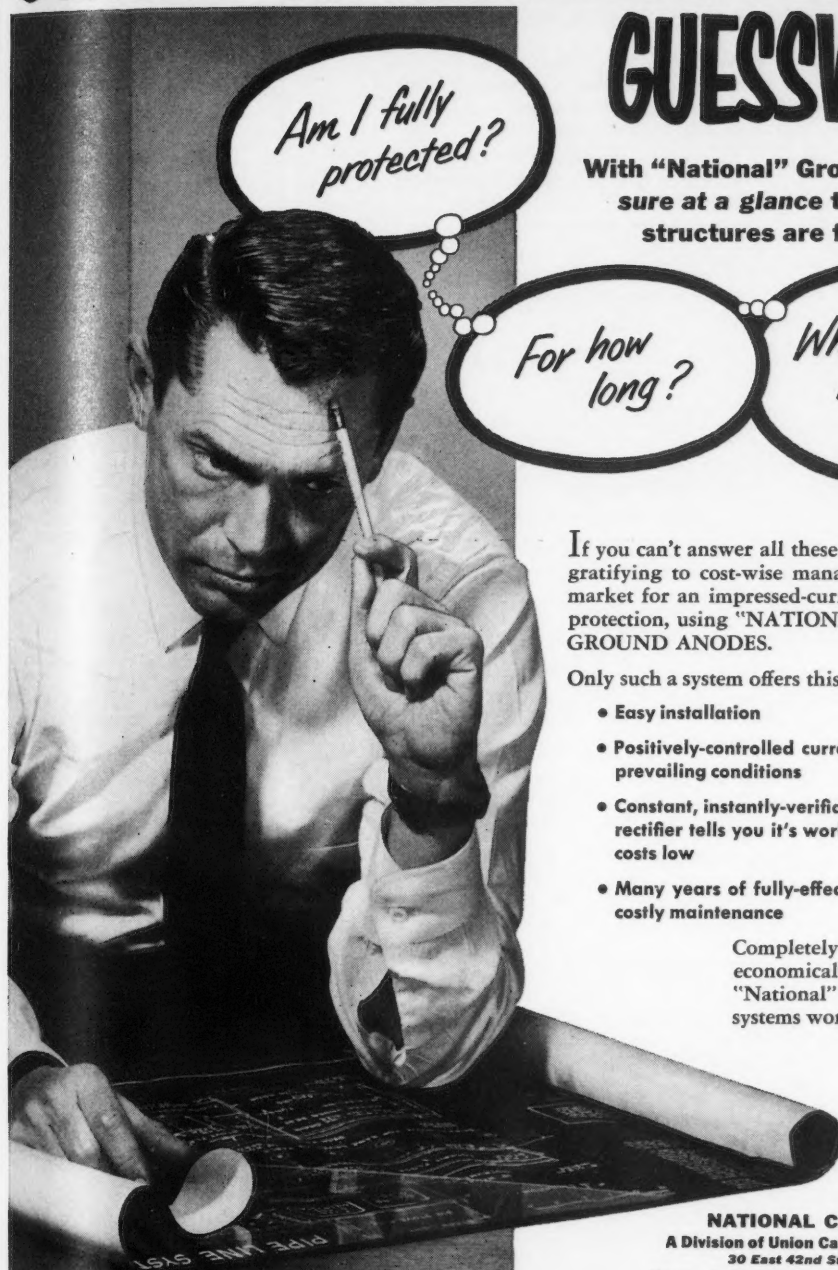
Other elements are sometimes added to give specific properties: to improve machinability, enhance scaling resistance, improve resistance to corrosion in specific, difficult cases.

Leading steel companies produce austenitic chromium-nickel stainless steels in all commercial forms. A list of sources of supply will be furnished on request.



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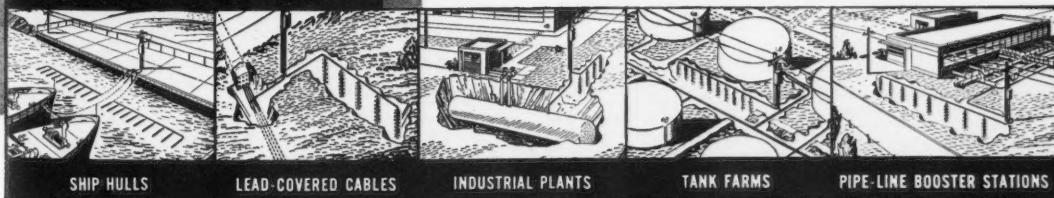
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(Continued on Page ix)

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(Continued from page viii)

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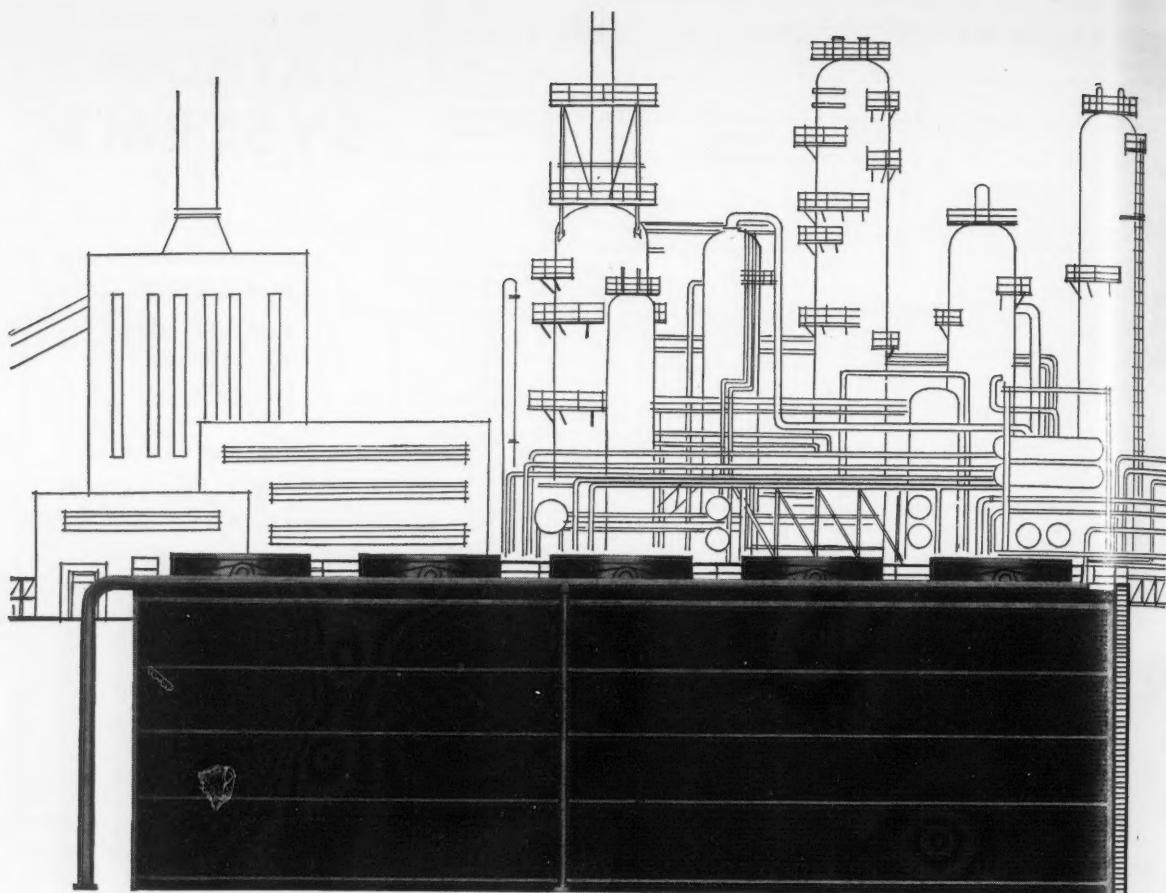
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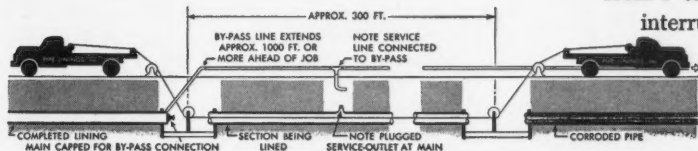


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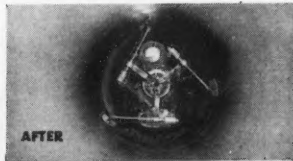
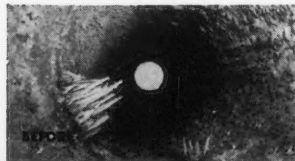
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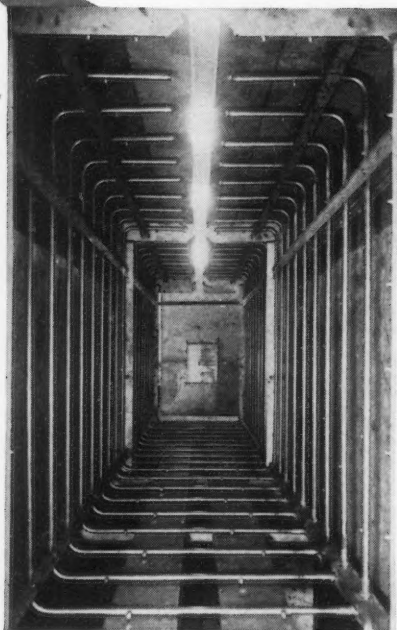
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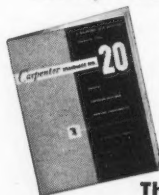
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This may be just the cure for severe corrosion headaches you've been looking for. Send for bulletin containing corrosion resistance, properties, performance results, application and fabricating data. A call to your local Carpenter Distributor or Representative will receive prompt attention to your inquiry.

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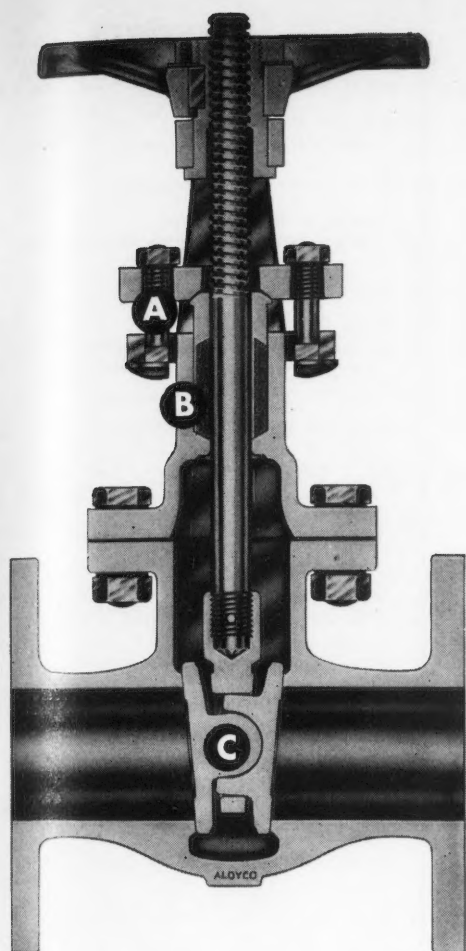
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Advanced features of these valves increase their corrosion-resistance

- Double disk ball-and-socket type wedges are free to rotate and are non-fouling in any position to assure pressure tightness on both seats.
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- Prevent valve corrosion from eating into your production and profits!

How? Look to Aloyco, the world's largest specialists in the manufacture of corrosion-resistant valves, for the valve design and alloy that will give lasting, maintenance-free performance.

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If you have a problem of valve maintenance or replacement because of corrosion, write to Aloyco's Corrosion Engineering Service about your own valve needs. Or call your nearest Aloyco distributor.

- A. Rocker type gland plates and guided gland followers.
- B. Teflon packing for stuffing box (optional).
- C. Double disk, ball-and-socket type wedges.

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This alloy was specifically developed to provide corrosion-resistance against a wide range of sulphuric acid concentrations and temperatures.

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- (a) To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.
- (b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.
- (c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.
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Organization and Aims of

Committee T-2D on Standardization of Procedures for Measuring Pipe Coating Conductance

By W. F. HUDDLESTON*

COMMITTEE T-2D (old designation TP-17) was formed for the purpose of standardizing a suitable procedure for measuring the coating conductance on buried pipe lines. It was thought that if all pipe line operators would follow a uniform procedure for making this determination in the field, they would be able to evaluate completed pipe coating jobs on an equal basis.

One of the first conclusions that the committee made was that it is physically impossible to measure coating conductance. Instead, "leakage conductance" is measured. Therefore, the committee says it is attempting to agree upon a satisfactory procedure to follow in the determination of the leakage conductance on a coated pipe line.

Another conclusion made by the committee and almost unanimously accepted by the participating members is that a problem in attenuation is being dealt with in principle.

After the committee members agreed upon the proper approach to make in working out the ultimate answer to the problem at hand, it was found that many variables were faced. For example, one prominent consulting engineer pointed out the necessity

of stating the soil resistivity whenever any value of leakage conductance is stated. It is easy to see the logic in his contention, for no one expects to find the same amount of leakage conductance for a coated pipe line submerged in sea water as would be found for the same line traversing rolling sand hills!!!

Determination of pipe coating leakage conductance can be used for many practical purposes. One leading pipe line organization worked out its own procedure and during pipe line construction specified the maximum permissible leakage conductance that would be acceptable for the completed coating job. Some states are attempting to write laws wherein pipe lines must be laid with a protective coating within a specified range of leakage conductance—although these states have expressed the issue somewhat differently. Other pipe line corrosion engineers are interested in making this determination to use in arriving at the amount of cathodic protection that will be needed, etc.

The problem at hand is a difficult one and the members already have considered the possibility of perpetuating the committee in order to revise the procedure from time to time because it feels that at best it can only agree upon a "tentative" procedure to follow in making this determination.

*Chairman, T-2D, Huddleston Engineering Co., Bartlesville, Okla.

Laboratory and Plant Evaluations Of Liquid Neoprene Coatings*

By R. B. SEYMOUR*

MANY DESIGNERS and some engineers who have become accustomed to specifying expensive alloys as materials of construction are continually seeking an inexpensive one-coat system as a universal solution to all corrosion problems. As a result, they are usually as receptive to the sales pitch of the non-technical coating salesman as the old time housewife was to the claims of the patent medicine peddler. Unfortunately, both are usually disappointed.

In spite of the erroneous suppositions of both the buyer and the seller, who expect a dollar's worth of poorly applied coating to solve a multi-billion dollar problem, there is a definite place for properly applied coatings in the battle against corrosion. However, even the best coating will fail prematurely unless it is applied on a properly prepared surface using a minimum of three coats to produce a thickness of at least 5 mils.

These minimum prerequisites are essential if the coated surface is to be exposed to splash and fumes of corrosive chemicals or if the protected surface is to be in continuous contact with an extremely mild corrosive solution. Protective coatings are not usually recommended for continuous exposure to liquid corrosives.

It should be emphasized that in spite of the designers' hopes and the peddlers' claims, the miracle coating has not been invented. If such a product should ever be produced, the impact on the entire economy will be so great that even the most illiterate citizen will be aware of the invention. Thus, the news will not be announced for the first time on the customers' doorstep by a non-technical coatings' salesman.

As in the case of other less important improvements, it might be anticipated that the information will be forthcoming from technical organizations, such as the National Association of Corrosion Engineers. In the interim, before the long sought coatings millennium occurs, it should be worthwhile to supply up-to-date accurate information on the best protective coatings available.

The Ideal Coating

From a practical point of view, based on the known limitations of available materials and application

Abstract

Liquid neoprene, among the coatings commercially available today, appears to be closest to the ideal coating, the author believes. The characteristics of several compositions of neoprene are given, application and curing techniques discussed, resistance to certain chemicals itemized and conformity with military and industrial standards compared.

Superiority of Type KNR over certain other compounds of neoprene is described and explained.

The author recommends on-the-job compounds as superior to one-part compounds. Specifications for various kinds of neoprene formulations are given, together with an explanation of fillers, applications and compounding techniques.

Numerous case histories of successful application of neoprene to protect plant against various corrosive environments are listed.

methods, the ideal coating should meet the following specifications:

1. It should adhere tenaciously to a properly prepared surface.
2. It should be spray or brush-applied readily to yield a pinhole-free film having a minimum thickness of 2 mils per coat.
3. It should dry or cure rapidly to a film which would be completely resistant to solvents, acids, alkalies and salts at temperatures up to 200 degrees F.
4. It should be unaffected by sunlight and weather.
5. It should have high tensile strength and elongation.
6. Its properties should remain unchanged for long periods of time under ordinary service conditions.
7. It should be available in a wide variety of colors.
8. It should not require special curing techniques and be reasonably non-toxic to the applicator.
9. It should have a long term record of successful performance.
10. It should be economical and available commercially.

It has been shown previously that based on performance indices, only neoprene, vinyl, styrene butadiene copolymers, chlorinated rubber, Saran and epoxy coatings should be considered for protection against splash and fumes in chemical processing plants.¹ A more critical examination will show that liquid neoprene coatings approach the ideal proposed specification more closely than any other commercially available coating material.

Adhesion

When applied over a chlorinated rubber base primer on a sandblasted steel surface, a one-inch strip deposited from a liquid neoprene requires a pull greater than 20 pounds for removal. Since the entire force operates at a small distance on the one-inch cross section, the actual adhesion value per unit

* A paper presented at the Tenth Annual Conference, National Association of Corrosion Engineers, Kansas City, Mo., March 15-19, 1954.
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area is obviously many times the force required to strip the film from the metal surface.

The U. S. Navy² requires a modified adhesion test in which a 15-pound weight attached to a one-inch strip must not drop more than one inch per minute. Few other organic protective coatings can meet this requirement.

Application

Properly compounded liquid neoprene coatings can be spray and brush applied to yield films at least 1.5 and 3 mils thick respectively. Especially compounded high solids coatings may be brush-applied in thicknesses ranging from 15 to 20 mils. As in the case of other coatings, none of these individual films can be claimed to be completely pinhole-free. However, such deficiencies can be usually overcome by multiple application. Few other organic protective coatings can be applied as films having the characteristic thickness of liquid neoprene coatings.

Chemical Resistance

Standard neoprene coatings compounded shortly before application, lose their solvent content within a few hours at ordinary temperatures. After several days, the resultant film becomes completely insoluble in aliphatic solvents, such as mineral oil, kerosene and gasoline. It should be pointed out that the tensile strength of the neoprene film is unaffected by small amounts of swelling. Volume increases greater than 100 percent are required before significant changes in tensile strength are noted.

Because of the high solids content and the inherent curing characteristics, there is much less tendency for subsequent coats to dissolve undercoats of liquid neoprene. There are a few other flexible coatings with similar solvent resistance but they require special solvent systems for application.

As shown in the following table, films from liquid neoprene are not attacked by most aliphatic solvents, water, solutions of most salts, inorganic alkalis and non-oxidizing acids, such as dilute sulfuric, phosphoric and hydrochloric acids at temperatures up to 200 degrees F. Neoprene films are attacked by oxidizing agents such as concentrated sulfuric acid, nitric acid, chromic acid, chlorine, chlorine dioxide, sodium hypochlorite and hydrogen peroxide. Neoprene is permeable to but not attacked by concentrated halogen acids, such as hydrochloric acid and hydrofluoric acid. Few other readily applied coatings possess the overall chemical resistance of liquid neoprene coatings.

It should be emphasized that from a practical view point, chemical resistance is dependent on both the chemical resistance of the compounded coating material and the application method. More complete chemical resistant data have been published previously^{3,4} but sufficient information is available in Table I to qualify liquid neoprene for most applications.

Sunlight and Weather

Properly compounded liquid neoprene coatings are usually superior to other elastomers in their

TABLE I—Chemical Resistance of Compounded Liquid Neoprene Films

	C	H		C	H
Acids			Gases		
Acetic, 10 percent....	N	N	Chlorine.....	N†	N†
Chromic, 10 percent..	N	N	Sulfur dioxide....	E	E
Citric.....	E	E	Hydrogen sulfide...	E	E
Hydrochloric.....	N*	N*	Organic Materials		
Nitric, 5 percent....	F	N	Ethyl alcohol.....	E	E
Sulfuric, 50 percent..	E	F	Benzene.....	N	N
Sulfuric, 93 percent..	N	N	Formaldehyde, 37 percent.....	E	E
Alkalies			Gasoline.....	G	F
Ammonium hydroxide.....	E	E	Industrial Applications		
Potassium hydroxide..	E	E	Paper mill.....	E	E
Sodium hydroxide....	E	E	Photographic industry.....	E	G
Salts			Steel pickling.....	E	E
Alum.....	E	E	Food industry.....	E	E
Trisodium phosphate..	E	E	Water and sewer applications.....	E	E
Sodium chloride.....	E	E			

* Permeation with concentrated solutions. Plant test required before use.
† Surface hardening. Plant test required before use.

Ratings:

E = No attack
G = Appreciably no attack
F = Some attack but usable in some instances
P = Attacked—not recommended
N = Rapidly attacked
C = Cold—75° F.
H = Hot—160° F.

resistance to sunlight and weather but are inferior to several other widely used organic protective coatings. The stability of most of the other top quality protective coatings is based on special compounding. Doubtlessly, the weather and sunlight resistance of liquid neoprene coatings could be improved if required. However, liquid neoprene has generally proved to be satisfactory when exposed to weather conditions in all parts of the country.

Physical Properties

A minimum tensile strength of 1200 psi and an elongation of 250 percent is required by the U. S. Navy for propeller shaft coatings. Such high elongation values have been obtained with other coatings through plasticization at the expense of tensile strength. Obviously, neoprene is one of the few protective coatings which possesses both high strength and elasticity.

Because neoprene does not require the addition of plasticizers to attain flexibility, its inherent elasticity is essentially permanent. Plastics to which plasticizers have been added may lose flexibility by plasticizer bleeding or solvent extraction but the elasticity of neoprene is destroyed only by oxidation. This process which involves attack of the unsaturated groups in neoprene may take place in the presence of chlorine, nitric acid, concentrated sulfuric acid or at very high temperatures. Few other organic coatings will withstand excessive oxidation. Most thermoplastic coatings will flow at 200 degrees F which is below the temperature required for surface hardening of neoprene.

Color Availability

Neoprene is light yellow colored—but red, yellow, gray and black liquid neoprene coatings have been produced. However, since it is customary to reinforce neoprene with carbon, most neoprene coatings are black. If both color and chemical resistance are required, it is often possible to over-coat neoprene films

with pigmented chlorinated rubber coatings which are available in a wide variety of colors.

Curing Method

Standard neoprene coatings must be compounded on the job at the time of use. Compounded coatings will cure fairly well at ordinary temperatures but maximum tensile strength is seldom attained unless the coating is heated to a temperature of 90 degrees C or above. If tensile strengths above 1000 psi are required, the curing process may be accomplished by heating with hot water or live steam. However, physical and chemical properties of room temperature cured neoprene coatings are superior to those of practically all other protective coatings. These physical properties are sufficiently high for almost all applications.

Liquid neoprene coatings are supplied as solutions in aromatic solvents, such as toluene or xylene. While these solvents are flammable and somewhat toxic, they usually amount to less than half of the total composition. It is recommended that the concentration of these solvents in the atmosphere never exceed 200 parts per million and that open flame or sparks be kept away during the application of liquid coatings containing solvents. The explosive limits of toluene and xylene are from 1 to 7 percent by volume in air.

Experience Record

Liquid neoprene coatings have been used successfully for ten years or more for protecting marine valves, water boxes and propeller shafts. Similar long term experience records have been obtained with fresh water condenser systems in large power plants. Successful use of neoprene coatings in steel mills and chemical processing plants has been observed for periods in excess of eight years. Chlorinated rubber and vinyl coatings are the only other readily applied commercial protective coatings having similar long term experience records.

Economics

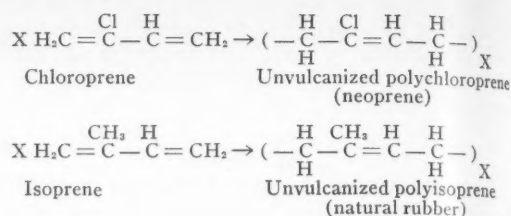
Some commercial liquid neoprene coating systems cost more per gallon than other protective coatings. Nevertheless, the cost per pound of solid neoprene deposited from solution is usually less than the cost of solids deposited from other protective coating systems. Because fewer coats are required to attain a coating of specific thickness, application cost is usually lower.

Because relatively expensive manufacturing equipment is required, liquid neoprene coatings are not as widely available as some of the more easily prepared coatings. Nevertheless, there are at least six known manufacturers and more than a score of distributors of commercial liquid neoprene coatings.

Chemical Composition

Neoprene is not a perfect material, but as previously explained, when properly compounded, it meets the major requirements for an ideal coating. As can be observed from the chemical formulas out-

lined below, it resembles natural rubber in its basic structure.



Unlike natural rubber, which may be vulcanized with sulfur, neoprene is usually cured through the use of basic compounds such as litharge or magnesia. The former is most widely used in liquid neoprene compounding. The polymer chains of properly cured liquid neoprene coatings are cross-linked to form a three-dimensional network which is no longer readily soluble in ordinary solvents.

The most widely used neoprene for liquid coatings is Type KNR, a sulfur-modified neoprene which, unlike the standard product, can be softened more readily by milling to form a high solids solution. This softening is accomplished by mechanical breakdown or milling of sulfur modified neoprene together with small amounts of piperidinium pentamethylene dithiocarbamate, usually in the presence of slightly larger amounts of tetraethyl thiuram disulfide. The action is more properly described as peptizing rather than plasticizing and should not be confused with the results obtained by the addition of liquid plasticizers to thermoplastic coatings. The total amount of additives customarily used is less than 4 percent of the weight of the sulfur modified neoprene.

While zinc oxide is an effective vulcanization agent for sulfur modified neoprene litharge is usually preferred because this type of compounding produces coatings with lower water absorption than can be produced with zinc oxide. In order to assure curing at room temperature, approximately three parts of a condensation product obtained by the reaction of butyraldehyde and monobutyl amine is usually added to approximately 15 parts by weight of litharge and the total is used with 100 parts by weight of sulfur modified neoprene.

Uncured neoprene is insoluble in acetone, ethyl alcohol and aliphatic hydrocarbons, such as gasoline. It has limited solubility in ethyl acetate but is readily soluble in higher molecular weight esters and ketones as well as in chlorinated solvents, such as carbon tetrachloride. It is readily soluble in aromatic hydrocarbons, such as toluene and xylene and most liquid compositions make use of these types of solvents.

Neoprene Type AC, which crystallizes very rapidly, has been used in adhesives and in some maintenance type liquid neoprene coatings. This non-sulfur modified type of neoprene is generally used with equal parts of terpene phenolic resin or other resins in adhesive formulations. This type of neoprene is soluble in the same type solvents as the sulfur modified product but solutions with high solids content cannot be obtained.

Standard Liquid Neoprene Coatings

An on-the-job compounded liquid neoprene coating may be applied as a 3-coat system over a chlorinated rubber primer in order to provide protection against splash and fumes. If severe corrosive or abrasive conditions are present, the film may be built up to thicknesses of 60 to 120 mils by multiple coat application.

In instances where abrasion is a factor, it has been considered good practice to apply a red liquid neoprene coating as a third or fourth coat. Thus, when the elastomeric surfaces becomes worn sufficiently to expose the red color, additional coats of compounded liquid neoprene may be applied. In any case, alternate coats of black and gray colored liquid neoprene provides a system which assures complete coverage on each coat.

A typical stabilized chlorinated rubber base primer should have a viscosity of 50 to 70 cps and a specific gravity of 0.9 to 0.95 at 77 degrees F. Its solids content should be not less than 15 percent by weight.

A typical liquid neoprene coating should have a solids content of not less than 54 percent of which at least 50 percent should be sulfur modified neoprene, a specific gravity of 1.1 to 1.2 and a viscosity of 1750 to 2500 cps at 77 degrees F.

One gallon of the compounded product should yield a coating of at least 2.5 mils thick when applied to 250 sq. ft. of primed surface. The deposited film, when cured, should have a tensile strength not less than 1200 psi and an elongation not less than 250 percent. The Shore Type A durometer hardness should be at least 65.

The pot life of the compounded liquid neoprene will vary with temperature and with the amount of compounding ingredients added. It is recommended that the compounded neoprene be kept at temperatures below 80 degrees at which a pot life of 25 to 35 minutes is characteristic. A decrease in pot life of approximately 5 minutes for each 5 degrees F increase in temperature can usually be predicted. A 25 percent reduction in accelerator content will extend the pot life approximately three times but twice as long a period will be required for the curing of liquid neoprene compounded in this manner.

It is customary to spray compounded liquid neoprene using a pressure of 30 to 40 pounds. At elevated temperatures, it is essential to add about 20 percent solvent to the compounded liquid neoprene to obtain good spraying properties.

Heavy Coat Type Liquid Neoprene

In order to fulfill the requirements for a liquid neoprene coating which can be applied in very thick coats, a special highly filled composition has been developed. This product is allowed to stand for 20 to 40 minutes at room temperature until it becomes quite viscous. It may then be brush-applied over a primed surface in the usual manner to secure a coating with a thickness of 15 mils per coat.

A typical high solids liquid neoprene coating should meet the following specifications:

Solids content not less than 57.5 percent, specific

gravity 1.1 to 1.15 and a viscosity of 750 to 1500 cps at 77 degrees F before compounding.

One gallon of compounded heavy solids product should give a coating having a thickness approximately 20 mils on 40 sq. ft. of surface. The cured film should have a tensile strength of not less than 500 psi, an elongation of not less than 100 percent and a Shore hardness of not less than 80.

Trowel Cements or Putties

High solids neoprene trowel cements or putties are available for filling crevices in steel before the application of liquid neoprene coatings and for the repair of damaged rubber rolls. Products of this type are compounded before use in the usual manner but, of course, must be applied with a trowel or high pressure spraying equipment rather than by brush or standard spraying equipment.

A typical liquid neoprene trowel cement should have a solids content of not less than 80 percent, of which at least 40 percent would be sulfur modified neoprene, a specific gravity of 1.1 to 1.4 and a viscosity of 800,000 to 1,200,000 cps at 77 degrees F.

Ready-Mixed Coatings

In spite of the fact that on-the-job compounded liquid neoprene coatings approach so nearly the ideal specifications and are readily compounded in the field, some maintenance men prefer a ready-mixed product even though its properties are inferior to the standard liquid neoprene coatings. Bake has said⁶ that while the two part system is inconvenient, he believes it is a small price to pay for the advantage of obtaining superior tank lining performance in general maintenance applications.

Arguments in favor of the ready-mixed coating have been based on the fact that the modern housewife buys cake mix rather than adding the ingredients separately. The comparison does not seem to be exactly analogous since cake quality is a matter of taste whereas chemical and physical tests readily show the differences between a low solids one-part maintenance paint and the high solids standard liquid neoprene compounded coating.

The ready-mixed so called maintenance coatings usually are based on the more crystalline, less soluble Neoprene AC rather than the sulfur modified Neoprene KNR. They may contain curing agents which limit the stability of the product to some extent. As might be concluded, the thickness of the films deposited from the one-part neoprene maintenance paints are much thinner than those deposited from the standard compounded liquid neoprene coatings. However, it is possible to load ready-mixed coatings with fillers such as mica to secure a heavy coating.

Because the so-called maintenance coatings do not cure completely, they have inferior resistance to chemicals and abrasion. In spite of the high cost and the previously cited disadvantages, the so-called neoprene maintenance coatings are superior to most thermoplastic protective coatings and they can be applied directly on sandblasted surfaces without a preliminary priming operation. Of course, a separate

priming system is required for applications where good adhesion is essential.

A typical neoprene maintenance coating should have a solids content of not less than 30 percent, a specific gravity of 0.9 to 1.05, a viscosity of 1500 to 3000 cps at 77 degrees F and a shelf life of at least three months.

One gallon of this type of liquid neoprene should deposit a 2 mil thick film on 175 sq. ft. of surface.

Neoprene Latex

As might be expected, with the great interest in household application of latex paints based on polyvinyl acetate and styrene butadiene copolymers, there is considerable interest in neoprene latices. Because of inherent high water absorption, neoprene latex has not been used to any great extent for protection against corrosives but it has been used to line tank cars containing hot liquid caustic. It also has been mixed with hydraulic cements to form specialty trowelling compositions. While these materials cannot be claimed to be completely chemical resistant, they do have applications in the waterproofing field.

The various types of liquid neoprene have been discussed generically. While it is not intended to imply that all neoprene coatings are the same, basic characteristics to be expected from a typical liquid neoprene coating should be itemized. Even though all neoprene coatings are based on the same raw material, there should be at least as much difference among commercial products as there is among automobile tires which, until a few years ago, were all based on natural rubber.

Case Histories

While compounding information and chemical and physical properties are of interest, most corrosion engineers are primarily concerned with performance. An attempt to give some idea of performance is made through a discussion of the following case histories:

Ductwork exposed to both corrosive acids and traces of solvents in a chemical plant was coated with 60 mils of a standard liquid neoprene coating. After eight years, the building was torn down as a part of a modernization program and the lining was found to be in perfect condition.

Concrete Pipe with a diameter of approximately 20 inches was coated with approximately 40 mils of compounded liquid neoprene over standard chlorinated rubber primer. The lined pipe was joined by an application of compounded neoprene trowel cement to the tongues and grooves. Before the application of liquid neoprene, the pipe line had to be replaced after 12 to 18 months of service. The present pipe line is still in use after three years exposure to sewage containing waste acids and corrosive salts.

Water Softening Equipment. A manufacturer who guaranteed his apparatus for a definite period was plagued with failures resulting from corrosion. Five years ago, a liquid neoprene coating shop was established and the corrosion complaints have been practically eliminated since that time. A 60 to 80 mil

coating is applied as a standard in this manufacturer's plant.

A Badly Cavitated Pump used in conjunction with the water supply of a large Eastern power plant was restored to use by an application of compounded liquid neoprene. In this restoration, the blades were sandblasted and primed and the cavities were filled in with neoprene trowel cement before the application of approximately 100 mils of the compounded liquid neoprene coating.

Pipe Lines. The liquid neoprene also was applied to many pipe lines of the same power company plant. In spite of the fact that the fresh water carried through the pipes contains a considerable amount of mud and solids, most of the previous troubles with corrosion and erosion have been eliminated. Needless to say, this firm has standardized on the use of neoprene coatings.

Tumbling Barrels used for grinding, deburring and to reduce surface porosity of coatings in plating plants normally are lined with wood. However, the wood is short-lived and picks up abrasives or other chemicals used in processing. Several shops are now using liquid neoprene to line tumbling barrels and find that the life of the flexible lining is three to four times that of the previously used wooden linings.

Engine Mountings in floor pits generally are subjected to drippage of water, oil and gasoline which leaks through the side openings and collects in the engine pits. This has been avoided in several plants through the use of liquid neoprene putty to form a resilient seal between the engine test stand mountings and the adjoining floor.

Condenser Tube Ends and Tube Sheets. Erosion caused by the impact of silt-containing water has been essentially eliminated in several installations through the application of 60 to 80 mils of uncompounded liquid neoprene over sandblasted and primed surfaces. In protecting condenser tubes, it is common practice to extend the liquid neoprene to five to six inches only and to feather out the inner edge to minimize additional turbulence.

Wooden Tanks. Some of the difficulties formerly encountered with shrinkage and warping of wooden tanks has been overcome by the application of compounded liquid neoprene between the staves before assembly. In this way, the tank is water tight from the beginning and does not have as great a tendency to develop leaks when the water level is reduced.

Exhaust Blowers. A lead coated exhaust blower in a chemical plant exposed to sulfuric acid mist and fumes at temperatures as high as 180 degrees F was accelerated beyond the critical speed so that the lead coating failed. This fan was sandblasted and coated with compounded liquid neoprene to a thickness of 100 mils. It was still in good condition after 14 months of continuous service. It should be pointed out that under the same conditions, 1/4-inch steel plate was eaten away in less than one month.

Rectifier Rolls on the wet end of a Fourdrinier ma-

chine in a paper mill formerly were made of heavy gauge brass or bronze. It has been found that these rolls can be made of lighter gauge steel which is sandblasted, primed and then dipped in compounded liquid neoprene to build up a coating approximately 125 mils in thickness. By curing in an oven while rotating, it is possible to secure a slick, smooth surface which not only has greater chemical resistance than the previously used materials but also is much more economical.

Coke Ovens. A comparative test of a large number of coatings in coke oven environment showed liquid neoprene coatings to be at least equal to the best of the other types of coatings tested.

Chemical Plants. Other comparative test in various areas of a large chemical plant also showed liquid neoprene coatings to be superior in chemical resistance to all other coatings tested.

Spiral Concentrators, so designed that when they are assembled they form a helix of five turns, were used in Florida to separate ilmenite from sand in a water slurry. Before application of liquid neoprene, the cast iron spirals were grooved very deeply in a short time. Based on several years' performance with the neoprene coated spirals, it is anticipated they will be satisfactory for approximately five years. Then it will be unnecessary to resandblast and prime because additional liquid neoprene can be applied to the worn neoprene surfaces.

Caustic Tank Cars. The iron pickup in uncoated caustic tank cars was sufficient to prevent its use for certain pulp and rayon processes. These tank cars now are coated with liquid neoprene and are giving good service. The iron content of the hot caustic is now below that required for almost all end uses.

Skid Resistance. In one plant, several accidents resulted from falls on wet wooden floors. The application of liquid neoprene on which was sprinkled abrasive granules produced a satisfactory skid resistant floor.

Acid Pickling Tank too large to be transported economically to a sheet lining shop and too small to justify sending trained rubber lining crews to the job site was coated with a compounded liquid neoprene lining averaging 100 mils in thickness on the sandblasted steel surface and this was protected by brick joined with a furan cement.

After operating satisfactorily with boiling acids for several years, the steel cracked, leaving an opening approximately 1/2-inch wide. The tank operated for ten days in this condition until it could be replaced. However, no acid leaked from it in spite of the pressure exerted on the liquid neoprene membrane.

Coal Chutes. One-quarter inch plates were replaced almost annually as a result of the abrasion caused by a slurry of finely divided coal which passed through steel chutes. After the upper portion of the chute was coated with 120 mils of compounded liquid neo-

prene, the plates were satisfactory after four years of service.

Fume Stacks. A temporary wooden stack carrying fumes from sulfuric acid at approximately 300° F was being rapidly destroyed. While it was known that the compounded liquid neoprene would harden rapidly at temperatures above 250 degrees F, its application was recommended with the object of prolonging the stock life by approximately three weeks. This interval was sufficient to permit the completion of a permanent stack constructed of brick joined with a furan cement. The compounded neoprene coating hardened as a result of the high temperature service but was still protecting the wood when the stack was dismantled.

Ship Propeller Shafts usually are badly corroded and pitted after a few months of service as a result of the attack of salt water. A neoprene coating program initiated over five years ago has permitted shafts to be used for several years before recoating.

A large number of other practical uses of liquid neoprene for prevention of marine corrosion have been reported.⁶ For example, neoprene coatings have been found to be successful on main sea valves, main circulator impellers, elbows, condenser heads and water boxes. Considerable promise has been shown through the use of liquid neoprene protective coatings on propeller, stern frames, flat keels, pump room sea valves and pump room sea chests in oil tanker service. In all instances, a 60-mil coating of a compounded liquid neoprene was used without additional heat for curing.

Conclusions

Liquid neoprene is presumably the nearest approach to an ideal protective coating. While in some instances the low solids one-package liquid neoprene coating may be used, the two-package on-the-job compounded liquid neoprene coating is recommended when protection is required against abrasion or splash or fumes from highly corrosive liquids.

Acknowledgment

The assistance of Dr. R. H. Steiner, G. L. Baumgartner and J. D. Fenstermacher of the Atlas Mineral Products Co.; L. S. Blake, V. A. Cosler and E. C. Fetter of E. I. du Pont de Nemours & Co. and K. A. Tator of K. A. Tator Associates in the preparation of this paper is gratefully acknowledged.

References

1. R. B. Seymour. Protective Coating Fundamentals for Southern Industry. Presented to the "Paint Clinic," Dow Chemical Co., Freeport, Texas, October 22, 1953.
2. Military Specification MIL-S-15058A, 28 April 1952, "Shaft-Covering, Rubber (Synthetic), Composition (For Solid Shafts)."
3. The Neoprenes. Neil L. Catton, E. I. du Pont de Nemours & Co., 1953, pages 218-221.
4. R. B. Seymour and R. H. Steiner. Plastics Equipment Reference Sheet No. 25—Neoprene Rubber, *Chem. Eng. Progress*, 49, No. 9, 510 (1953).
5. L. S. Blake. Paper presented at St. Louis Section, NACE, Jan. 21, 1952.
6. W. N. Damonte and T. T. Wilkinson. *Marine Engineering & Shipping Review*, October, 1951.

Causes of Corrosion in Deep Well Water Pumps in Israel*

SEVERE DAMAGE to components of deep water well pumps in irrigation systems in Israel has been traced in part to galvanic currents created by temperature differentials, incompatible metals and to potential differentials between wells connected by the piping system. Figure 1 shows corroded stainless steel shaft of a 20-stage 10-inch pump. Figure 2 shows corrosion in the discharge bowl at the multiseal lantern gland.

Stainless steel turbine shafts are cathodic to the cast steel impeller parts, combining with bronze components to make a cathode of considerable surface area. Low resistance paths exist between rotating and stationary parts of the pump.

Figure 3 illustrates the results of a potential survey on a well which failed after 4½ months' operation. Potentials recorded were against a copper copper-sulfate half cell. Measurements taken in summer time in dry soil. Potential differences were: Well casing to ground, .55 v; water main to ground, .45 v. A current of about 100 ma was flowing from the well casing to the water main. Potential differences between casing and water in the well are shown.

Figure 4 illustrates the arrangement of another well with an 8-inch locally made 13-stage pump. The

* Compiled from information supplied by D. Spector, Tel Aviv, Israel.



Figure 1—Corroded stainless steel shaft from 20-stage pump.



Figure 2—Corrosion in discharge bowl at multiseal lantern gland.

Abstract
Among the causes of corrosion of deep well water pumps in Israel are galvanic currents caused by temperature differential cells between the upper and lower portions of well liners and pump components; galvanic corrosion from incompatible metals; and discharges of current from interconnected piping systems. These currents were held responsible for damage to screens and to pump components, especially driving shafts, which in some cases was so serious as to cause abandonment.

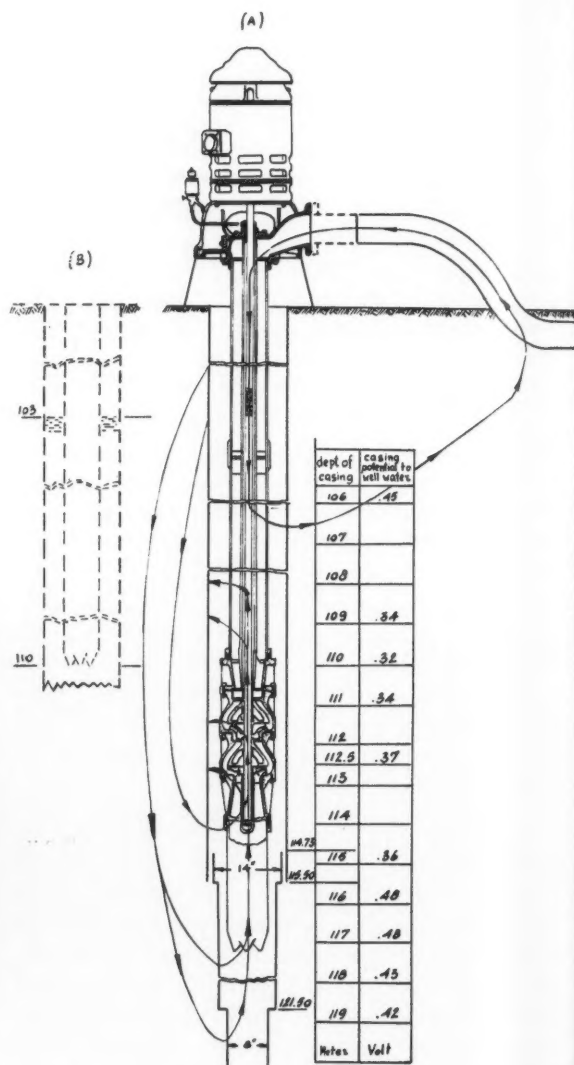


Figure 3—Potential survey of 20-stage pump (A) and 17-stage pump (B). Arrows show probable course of current.

eight and 10-inch stainless steel screen sections were electrically continuous with the steel casing. Sand appeared in this well after three years' pumping.

Galvanic action between the screen and casing was found concentrated along the pump column facing the 10-inch screen, resulting in holes and pitting. The steel shaft and column were badly attacked and had to be repaired. The well, although put to use again after installation of a bronze screen, was abandoned after six months when sand appeared again.

More attention must be given to galvanic corrosion in pumps caused by incompatible metals. Insulation of pump discharge from pipelines is advisable. Some consideration should be given to measures to control thermogalvanic cells and more attention to the installation of screens is needed.

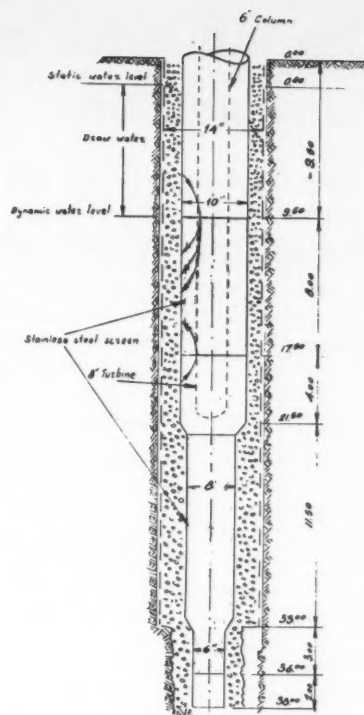


Figure 4—Diagram of well where 13-stage pump failed.

ERRATUM

Robert Mallet—Pioneer Corrosion Engineer. By Wilson Lynes. *Corrosion*, Vol. 10, No. 2, 59-62 (1954) Feb.

Page 60, Col. 1, Paragraph 4, Line 4: substitute the following:

steel, 10 different organic coatings, galvanized iron, correcting the spelling of the word "different."

Page 60, Col. 2, Paragraph 1: Substitute the following for the first three lines:

The purpose of the second period of exposure of the cast irons and organic coatings was to permit predicting with greater certainty the actual loss of changing the first word in line three to "predicting."

Page 62, Col. 2, under the heading "References" substitute the following for Reference 23:

23. U. R. Evans. *Chemistry and Industry*, 986, October (1952).

Changing the number 986 from boldface to lightface.

The Influence of Corrosion on The Cracking of Pressure Vessels*

By H. R. COPSON*

Summary

CORROSION will not produce cracking unless it is combined in some way with stress. The most serious damage occurs when stress and corrosion combine to produce certain mutually accelerating effects. This may take the form of what is called stress corrosion cracking, involving static tensile stresses, or corrosion fatigue, involving cyclic stresses.

Corrosion can combine with stress to produce less spectacular damage. Local corrosive attack produces stress concentrations at the notches, pits and grooves which may be formed, and this ultimately can lead to cracking at the weakened positions. If corrosion takes the form of intergranular attack, tensile stresses such as exist in pressure vessels would tend to open up the metal and keep the attack going, and thus ultimately lead to cracking.

It should not be inferred that stress always increases corrosion. In the absence of cracking, experience indicates that the effects of normal amounts of static stress on general corrosion are small. No recognized problems exist in this connection.

In certain circumstances corrosion can produce another type of damage which is associated with charging the metal with hydrogen. The hydrogen can produce embrittlement, blistering or fissuring, and thus seriously weaken the metal.

The effects of corrosion on pressure vessels may often be minimized by intelligent design, by reduction where possible in internal or applied stresses, and by choice of materials suitably resistant to their expected service environment. Control of the environment itself, by dilution or lowering its temperature is sometimes practical, and inhibitors are effective in certain instances. Paints and protective coatings, and cathodic protection or use of sacrificial anodes are sometimes employed.

Many of the factors involved in the corrosion of pressure vessels require clarification and could well be the subject of profitable research. A great deal of work along these lines is being actively pursued and it is significant that about half of the literature references were published within the past five years.

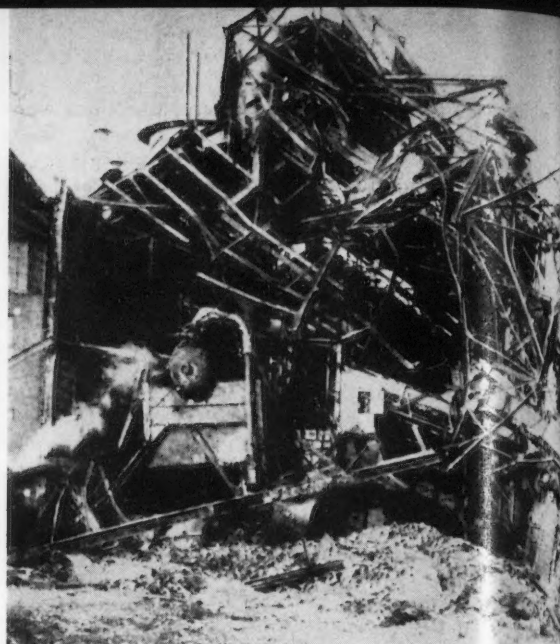


Figure 1—Power plant after explosion due to caustic embrittlement of steam boiler.²¹

Abstract*

The author reviews the numerous theories and assumptions advanced to explain the failure by corrosion of metals under stress. He makes recommendations concerning design criteria applicable to vessels likely to be subjected to simultaneous corrosion and stress and differentiates among stress corrosion cracking, corrosion fatigue, local attack, intergranular attack, effect of stress on general corrosion and effects of hydrogen generated by corrosion; and outlines fields of future research into the whole gamut of phenomena associated with the problem.

Under the heading "Stress Corrosion Cracking," descriptions, theoretical causes, examples and recommendations for avoiding or minimizing caustic embrittlement are given. Similar information is given on stress corrosion cracking of iron, copper alloys, aluminum alloys, stainless steel, magnesium alloys, other metals, molten metals. Included also are tests to predict stress-corrosion cracking, and recommendations for prevention of stress corrosion cracking.

Under the heading "Corrosion Fatigue," conducive environments, theory, testing recommendations, fatigue data, identification of fatigue and means of protecting against corrosion fatigue are covered.

The article includes 18 figures and 101 references.

* This abstract was not a part of the original article published in *The American Welding Journal*.

Forms of Corrosion

If corrosion were a uniform wasting away of the surface, it could easily be provided for by the design engineer and would present no difficult problems in pressure vessels. Corrosion, however, takes many different forms. The forms might be classed as uniform attack, local attack, galvanic attack, corrosion cracking, corrosion-erosion and subsurface attack at high temperatures.

Uniform attack is a general wasting away of the surface such as might occur in acids, or in many other solutions or as high temperature oxidation. It is easily expressed as a uniform corrosion rate in

* Reprinted from *The American Welding Journal*, 32, 75s-91s (1953) Feb. The article was prepared under sponsorship of the Materials Division, Pressure Vessel Research Committee, Welding Research Council.
* International Nickel Co., Inc., Research Laboratory, Bayonne, N. J.

milligrams per square decimeter per day or in inches per year. Likewise it is easily taken care of in pressure vessels by allowing enough extra thickness to take care of the expected corrosion damage during the life of the equipment. Sometimes, uniform attack is not obvious in that the corrosion products may remain in place, and the dimensions and superficial appearance of the material may not change. This occurs in the so-called graphitic corrosion of cast iron where the metal is destroyed but the graphite is left intact.¹ It may also occur in the dezincification of brass alloys where the zinc is removed and a porous layer of copper is left behind.² In either case the structure would have lost greatly in strength without this being readily apparent.

Unfortunately corrosion is not always uniform but frequently shows a tendency to localize, with the attack occurring in critical locations or as scattered pitting. Such local attack might be caused by differential aeration cells,³ by concentration cells⁴ or by impingement attack.⁵ It might occur at breaks in scale, under deposits or in crevices.⁶ Pitting, of course, is more damaging than the same weight loss spread uniformly over the surface. Pitting causes concentration of stresses at the root of the pit, and this can be particularly bad where the pits line up in rows or where the local attack forms grooves and notches.

Galvanic corrosion occurs when a current flows between dissimilar metals in contact in a conducting electrolyte.⁷ It is of interest in pressure vessels primarily where it may cause deep local attack. This might occur where the anodic member of the couple has a relatively small area or where the conductivity of the liquid is insufficient to spread the galvanic corrosion over an appreciable area. If, for any reason, the current density is low, the galvanic corrosion will not be serious.

The term corrosion cracking includes all the instances where corrosion is associated with cracking. These have already been outlined and are considered in detail below. The main forms are stress-corrosion cracking and corrosion fatigue, but local attack, intergranular attack and hydrogen embrittlement may lead to cracking under suitable conditions.

Corrosion-erosion involves those conditions where erosion and corrosion go hand in hand⁸ as can occur in pressure vessels subject to high velocity flow at an inlet. Removal of protective corrosion products by erosion allows the metal to continue to deteriorate at its initially rapid rate. Local impingement attack can form small bare areas which are anodic to adjacent filmed areas, and thus lead to rapid local corrosion and pitting. Cavitation erosion, fretting corrosion and wire drawing all involve both erosion and corrosion. While some form of corrosion-erosion might show up in pressure vessels, it generally does not lead directly to cracking.

Corrosion at high temperatures sometimes causes another form of attack, namely damage beneath the surface. This might take the form of internal oxidation, of carburization, of sulfidation, or of some combination of these. Hydrogen under pressure may cause decarburization and the development of voids

and fissures.⁹ It is obvious that such subsurface attacks can seriously weaken and embrittle the metal. It must be considered in pressure vessels operating at high temperatures.

It is evident that the various forms of corrosion overlap and are not always sharply defined. Several forms of attack may be present simultaneously. The field is large and complicated with many ramifications. Consultation with experienced corrosion engineers is usually desirable in the analysis of a particular failure. In the design of new equipment close cooperation between the design engineer and the corrosion engineer is well warranted and are often highly essential.

Corrosion From a Design Viewpoint

From a corrosion standpoint, suitable materials can sometimes be chosen on the basis of prior knowledge and experience.^{3,9-11} More often, and particularly when new processes or environments are involved, corrosion tests are required.¹²⁻¹⁴ For best results the tests should be made under actual operating conditions, although the variables involved can often be studied to advantage under controlled conditions in the laboratory. Since corrosion behavior is altered in manifold ways, it is not wise to cut corners in corrosion testing. No safe short cuts or accelerated tests are known.

For example, to simulate corrosive conditions in a pressure vessel operating at the boiling point, it might seem logical to conduct immersion tests in the boiling liquid. However, if heat is being applied from the outside, the skin temperature of the metal may be appreciably higher than that of the liquid. This hot wall effect has been known to greatly accelerate and localize corrosion. Numerous illustrations of this sort could be cited. The point is that unless the service conditions are reproduced in all their ramifications, the whole story may not be brought out, and the results may even be misleading.

Reliance should not be placed entirely on weight losses or inches penetration per year. It should be known if the strength of the material has been damaged, as by intergranular corrosion, local attack or pitting. It is helpful if there is supplementary information, involving changes in corrosion rates with time, the effects of relative velocity between the metal and its corrosive environment, and the effect of static or cyclic stresses.

Once the corrosion picture has been explored and suitable materials have been selected, design becomes an important factor in preventing and minimizing corrosion. For example, if corrosion is greatest near the liquid line, it may be possible to provide extra metal thickness in this vicinity. If corrosion is greater near one end of a pressure vessel it may be practicable to design the vessel so that it can be turned end for end. If there is increasing corrosion near the entrance end of heat exchanger tubing, it may be possible to insert short replaceable inserts in the ends. Corrosion can often be minimized by frequent cleaning and by controlling moisture and oxygen.

The design should be such as to facilitate replacement of parts subject to corrosion. If practicable such parts should be interchangeable. The equipment should be designed for complete drainage and easy cleaning. Exceeding normal capacity should be avoided. Galvanic effects between dissimilar metals should be avoided.¹⁵ Impingement, turbulence, localized heating, stagnant areas, crevices and stress concentration should be avoided. A number of authors have considered the influence of design in greater detail.¹⁶⁻¹⁹

Stress Corrosion Cracking

Stress corrosion cracking is something which the design engineer should always keep in mind in specifying materials, particularly in the case of pressure vessels. The presence of internal stress should always be taken into account when deciding the magnitude of externally applied stresses to which the equipment can be safely subjected. Unfortunately there are no guiding rules which can be followed. About all that can be said is that stress corrosion cracking is specific both for the metal and for the environment. In certain special environments the presence of tensile stresses may lead to the cracking of certain metals. With other environments or with other metals or alloys no difficulty is encountered. Reliance must be placed on practical experience or on laboratory or field tests.

The term stress corrosion cracking is used to indicate the combined action of static tensile stress and corrosion which leads to cracking. The principal factors are the magnitude of the stress, the nature of the environment, the length of time involved and the internal structure of the alloy. These factors are not independent, but interact, one accelerating the action of another. Their relative importance varies with conditions.

If stress corrosion cracking is to occur there must be tensile stresses at the surface. The stresses may be internal or applied, the two types being additive. Examples of internal stresses are those produced by deformation during cold work, by unequal cooling from high temperature and by internal structural rearrangements involving volume changes. Stresses induced when a piece is deformed, those induced by press and shrink fits and those near welds, rivets and bolts may be classed as internal stresses.

In many cases these concealed stresses are of greater importance than actual operating stresses. This is true also of pressure vessels, except perhaps for those operating at loads which are high in relation to the strength of the material. When the factor of safety required in design is considered, operating stresses are generally low enough to be of comparatively little importance, except as they add to the internal stresses.

The actual stresses may vary greatly from point to point within the metal, and in some locations are much higher than the average value. A nonuniform stress distribution is expected, nevertheless a high localized stress is considered more damaging than a uniform load. Generally tensile stresses in the neighborhood of the yield strength are present in

stress corrosion cracking failures, but failures are known which have occurred at much lower stresses. In any case the stress levels are low enough so that normally a great deal of general corrosion could be tolerated. The interaction of the stress and corrosion produces cracking where it would not otherwise be expected.

Stress corrosion cracking has been observed in almost all metal systems. Yet for each metal specific environments are required to produce it. No stress corrosion cracking has occurred in a vacuum. The environment that induces cracking frequently attacks the metal only superficially if stresses are absent. Many of the environments that cause cracking tend to produce a pitting type of corrosion.

One of the curious aspects of stress corrosion cracking is the wide difference in time required for failure, which varies from a matter of minutes to many years. Associated with this is the probability of cracking. Specimens which are apparently similar may not behave alike, with perhaps 40 per cent cracking in a short time, and the rest remaining uncracked for a much longer time. Laboratory tests require severe conditions to produce cracking in reasonable time, whereas in service much milder conditions may cause cracking in the longer time available.

Considerable time may be required before corrosion proceeds to the extent that it begins to be accelerated by the tensile stresses present. The more severe the corrosive conditions and the higher the stress level the sooner this will happen. With some alloys there is an incubation period, during which precipitation or other structural changes may be occurring. For example, aluminum-magnesium alloys (over 6 per cent magnesium), immediately after heat treatment, may not show any susceptibility to cracking in accelerated laboratory tests, but after aging at room temperature for 6 months, stress corrosion cracks may form rapidly in the same test.

As just indicated the internal structure of the metal or alloy can be of considerable importance. The internal structure is dependent upon composition, upon the method of fabrication and whether the metal is as-cast, hot worked or cold worked. It is also dependent on thermal treatments and the extent of natural aging.

There have been numerous reviews and books on stress corrosion cracking.^{9, 20-24} There is also a voluminous literature. This should be consulted for detailed information. The more important instances of stress corrosion cracking are discussed below.

Caustic Embrittlement

A well-known example of stress corrosion cracking is the caustic embrittlement of steel in steam boilers.²⁵ The cracking is associated with the presence of sodium hydroxide in the boiler and hence the name caustic embrittlement. The metal away from the cracks, however, is ductile and not brittle. When a boiler lets go because of caustic embrittlement, results can be disastrous as illustrated in Figure 1.²⁶ Other examples of severe explosions have been cited by Zapffe.²⁷

Figure 2

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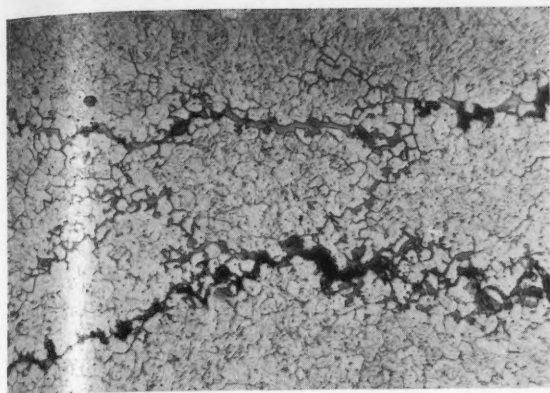


Figure 2—Caustic embrittlement of steel exposed to 50 percent caustic soda at 250 degrees F. X 250.

The cracking is said usually to be predominantly intercrystalline, and Figure 2 is an illustration of this. This photomicrograph was prepared from the steel of an autoclave exposed to 50 per cent caustic soda at 250 degrees F and 400 psi. This is perhaps a more concentrated solution than normally encountered in steam boilers, but it is an excellent example of caustic embrittlement just the same. Oxides are present in the cracks, which is typical. In other cases the cracks may be partly transcrystalline, or even, as illustrated in Figure 5, predominantly transcrystalline. It used to be thought that stress corrosion cracks were characteristically intergranular, but many cases are now known where the cracking follows a path across the grains.

In steam boilers the caustic present concentrates at small leaks or capillary spaces. The caustic concentration builds up to high values at such places. High tensile stresses must be present, of course, and usually the cracking takes place along rows of rivets where there may be slight leaks. Salt deposits have been observed in some cracked rivet seams.

In laboratory tests a U-bend specimen with a bolt through the legs is convenient for studying caustic embrittlement. Specimens of this nature are shown in Figure 3. The U-bend specimen has tensile stresses in the outer fibers in the neighborhood of the yield point, and high stress gradients such as frequently occur in practice. Any cracking is located on the outside of the bend as shown in the figure. The white material in the cracks is residual caustic. These steel specimens were exposed to boiling 33 percent sodium hydroxide containing 0.1 per cent lead oxide for 14 days.

U-bend specimens of this type were used by Berk and Waldeck²⁸ to outline dangerous concentrations and temperatures of caustic. They obtained no cracking in 30 days or longer at concentrations below 15 per cent or above 43 per cent or at temperatures below 180 degrees F. However, under long-time service conditions, cracking has been observed well outside these limits.²⁹ Also it is known that constituents present in small amounts may act as accelerators or as inhibitors of the cracking.

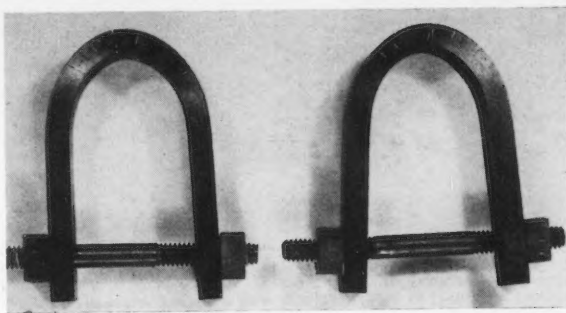


Figure 3—Steel U-bend specimens after exposure for 14 days to boiling 33 percent sodium hydroxide containing 0.1 percent lead oxide. Approx. X $\frac{1}{2}$.

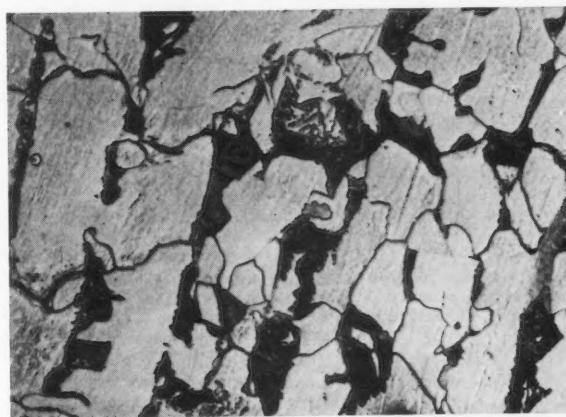


Figure 4—Intercrystalline cracking of steel U-bend specimens after 15 days in boiling 33 percent sodium hydroxide containing 0.1 percent lead oxide. X 500.

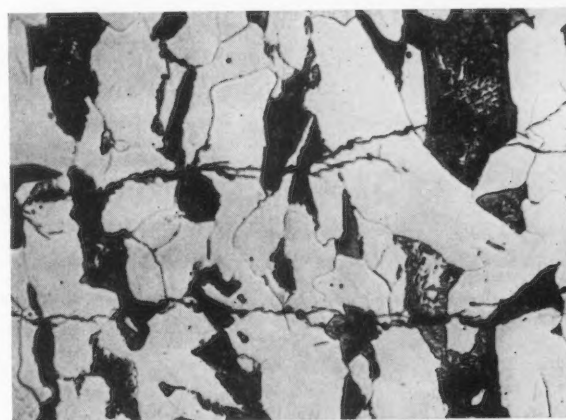


Figure 5—Transcrystalline cracking of steel U-bend specimens after 12 days in 33 percent sodium hydroxide containing 0.3 percent sodium silicate at 300 degrees F. Same steel as Figure 4. X 500.

In laboratory tests it is difficult to obtain consistent behavior in pure caustic. Cracking is readily produced by adding certain oxidizing agents or accelerators. Thus cracking in boiling 33 per cent sodium hydroxide can be consistently obtained by the addition of 0.1 per cent lead oxide. Figure 4 illustrates the intergranular nature of the cracking in steel U-bend specimens exposed to this media. Crack-

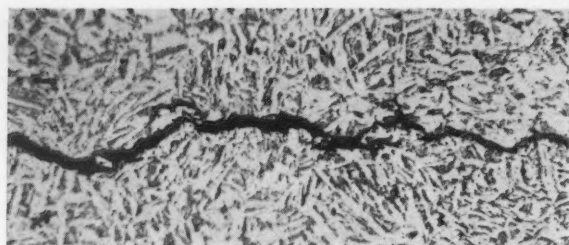


Figure 6—Transcrystalline cracking of steel U-bend specimens exposed for six days to water saturated with a 50:50 mixture of hydrogen sulfide and carbon dioxide at 100 degrees F. X 500.

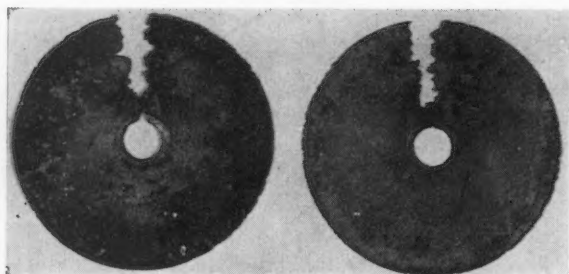


Figure 7—Stress corrosion cracking of stainless steel around stenciled identification marks and at machined edges. The specimens were exposed in 12 percent hydrofluoric acid containing 0.2 percent fluosilicic acid. X 2/3.

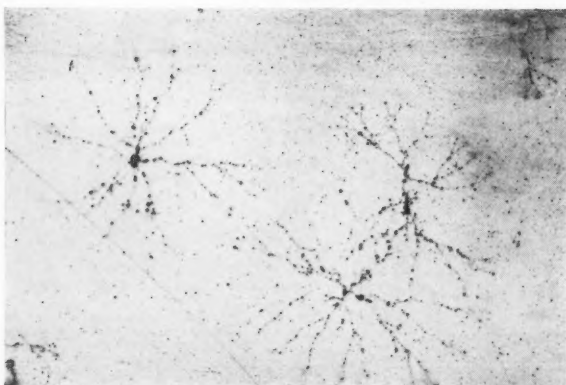


Figure 8—Stress corrosion cracking of stainless steel kettle handling a baked bean sauce high in chlorides. Same size.

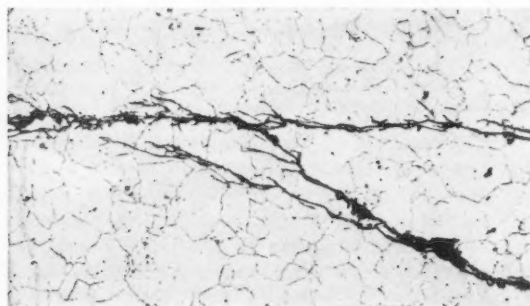


Figure 9—Transcrystalline nature of the stress-corrosion cracking of stainless steel. X 100.

ing can also be consistently obtained under similar conditions by the addition of 0.3 per cent sodium silicate. Figure 5 shows that under these slightly altered conditions the cracking was transcrystalline. Figures 4 and 5 are for the same steel and practically identical conditions except for the change in minor constituents in the caustic. Other stress corrosion cracking systems are known where slight changes in conditions have changed the path of the cracking. This fact is not explained by some of the theories of stress corrosion cracking.

Under service conditions caustic embrittlement is sometimes avoided by adding inhibitors of the cracking to the water. Thus tannins, lignins, quebracho extract, waste sulfite liquor, sodium nitrate, sodium phosphate and other additives have been beneficial in some cases.

An embrittlement detector has been devised which can be attached directly to a pressure vessel to determine whether or not the water is capable of producing caustic embrittlement.³⁰ The detector has a base which consists of a rectangular block with a hole through which the water circulates. The test specimen is clamped to this base. It is bent and maintained under stress by means of an adjusting screw which passes through the specimen and presses against this base block. A small hole conducts the water from the base block to the contact surface between the base and the specimen. By correct setting of the clamping nuts and adjusting screw a very slow leak of steam is established. Thus a concentrated solution forms under the bent area of the specimen. If the water is embrittling and sufficient time is allowed, such as 30 days or more, the specimen will crack. If the water is not embrittling no cracking will occur.

All steels are not equally susceptible to caustic embrittlement. Deoxidation practice and the residual elements present have some effect. However, the improvements have been minor and no steel has been devised which is completely resistant. Low-alloy steels crack as readily as plain mild steel.^{27, 29}

A welded construction is sometimes recommended as being superior to a riveted construction, the argument being that this should prevent the concentration of caustic at leaks and capillary spaces. Welds are apt to introduce high internal stresses, however, and welded pressure vessels have failed by caustic embrittlement.³¹ As-welded steel tanks are recommended for caustic service up to 140 degrees F, but for higher temperatures welded tanks must be stress relieved.²⁹ A low-temperature stress relief of welds has been proposed.³² This consists of heating a narrow band each side of the weld to 350-400 degrees F and quenching. This produces localized stretching with a resultant decrease in stress. Of course, where practical, a full stress relief anneal of the entire vessel is far safer.

Nickel cladding has been used successfully to prevent caustic embrittlement. Where the clad areas are joined by welding care must be taken to insure sound welds. The cracking illustrated in Figure 2 was in an autoclave lined with nickel. The welds

were defective and allowed the caustic to contact the steel with the result that cracking of the steel occurred.

Lowering the tensile stresses present when possible is a standard means of preventing caustic embrittlement. This and other means of preventing stress corrosion cracking are considered further below.

Stress Corrosion Cracking of Iron

In addition to caustic embrittlement, iron and steel alloys are subject to rapid stress corrosion cracking in some nitrate solutions.³³ Cracking has occurred in concentrated calcium nitrate and concentrated ammonium nitrate. Highly stressed bridge cable wire cracked in dilute ammonium nitrate and in dilute sodium nitrate, but not in distilled water, dilute ammonium sulfate, ammonium nitrite or sodium hydroxide.³⁴ Cracking has occurred in concentrated nitric acid and also in dilute nitric acid containing manganese dichloride as an accelerator.³⁵ All these failures were largely intergranular.

Transcrystalline cracking has been observed in tanks holding certain gases under pressure. This has been attributed to moisture and traces of hydrogen cyanide³⁶ and to moisture and traces of hydrogen sulfide.³⁷ Figure 6 shows the transcrystalline cracking of steel U-bend specimens exposed for 6 days to water at 100 degrees F saturated with a 50:50 mixture of hydrogen sulfide and carbon dioxide.³⁸ Embrittlement by hydrogen may be involved in this cracking. Cracking of similar nature has occurred in high-pressure gas condensate wells containing hydrogen sulfide and carbon dioxide.³⁹ Ammonium thiocyanate seemed important in the stress corrosion cracking of steel gas mains.⁴⁰ Undoubtedly additional corrosives which cause stress corrosion cracking of steel will come to light. This should be considered in exposures involving new chemicals.

Stainless Steel

Figure 7 shows an instance of stress corrosion cracking of Type 302 stainless steel. Disk-shaped specimens were immersed for 7 days in a solution containing 12 per cent hydrofluoric acid and 0.2 per cent fluosilicic acid at 182 degrees F. Cracks formed around stenciled identification marks causing these sections of the specimens to fall away completely. Cracks can also be seen at the machined edges.

Figure 8 shows another instance of stress-corrosion cracking, this time of a Type 304 stainless steel kettle handling a baked bean sauce which was high in chlorides. The cracks had a radiating pattern and tended to line up with small sharp pits.

Stress corrosion cracks in stainless steel are usually transcrystalline. A typical example is shown in Figure 9. These cracks occurred in a specimen exposed to a boiling calcium-magnesium chloride brine. Intergranular cracking has been observed, but only when the heat treatment has been such as to make the stainless steel susceptible to general intergranular corrosion.

The stresses required to cause cracking in the stainless steels sometimes seem comparatively low,

a stress of less than 20,000 psi being reported sufficient by Scheil in one instance.⁴¹ Some Type 347 tubing was found to be susceptible to cracking in boiling calcium magnesium chloride brine after stress-relief annealing from 1350 degree F, but resistant to cracking after a slow cool from 1600 degrees F. Slow cooling is essential as quenching stresses may be sufficient to cause cracking.

Ferritic stainless steels are less susceptible to stress corrosion cracking than the austenitic alloys. Generally, cracking cannot be avoided by shifting from one austenitic grade to another, although there may be real differences in behavior, with increased corrosion resistance and increased austenitic stability being helpful.⁴¹

A thorough review of environments causing stress corrosion cracking of stainless steels was prepared recently by Nathorst.⁴² The number of environments seems large, but in spite of this the austenitic chromium nickel stainless steels perform satisfactorily under many service conditions.

Most cases of cracking involve the presence of chloride ions, particularly if the solution is acid. Hot concentrated solutions of chlorides of magnesium, calcium, barium, cobalt, zinc, lithium, ammonium and sodium all cause rapid cracking.⁴³ Cooler or more dilute solutions may be satisfactory. Organic chlorides, such as ethyl chloride, which decompose in the presence of moisture to form hydrochloric acid may cause cracking.⁴⁴

In many cases where some other environment was thought to cause cracking, closer investigation has shown that chlorides were actually present, even if only as an impurity. Thus cracking has been reported in sulfite waste liquors of the cellulose industry, but in almost every case brackish waters were used. Likewise cracking has been reported in steam and hot water, but in such cases it appears that the design is such as to allow local concentrations of chlorides.

Stainless steels are susceptible to stress corrosion cracked in hot concentrated caustic solutions. The presence of sodium sulfide and reducing substances is said to increase the danger of cracking in caustic. Rees has reported cracking in moist hydrogen sulfide.²⁴ Cracking has also been reported in some other environments.⁴²

Copper Alloys

Perhaps the best known example of stress corrosion cracking in copper alloys is the season cracking of brass,⁴⁵⁻⁴⁷ so-called because the cracks resemble those in seasoned wood. Exposure to moist ammoniacal atmospheres is believed to be necessary to produce the cracking, but oxygen and carbon dioxide have a contributing effect. Cracking is fast in contaminated atmospheres, but has occurred under apparently normal outdoor and indoor conditions. Evans has speculated on the role of ammonia in promoting the cracking.²⁴

Susceptibility to cracking increases with tensile stress. Stresses of 12,000 to 20,000 psi readily cause cracking, but cracking is rare with stresses below 12,000 psi. Susceptibility to cracking increases

greatly with zinc content. Alloys with 85 to 90 per cent copper are practically immune, and with 80 per cent copper they are fairly free from cracking. Two-phase brass compositions, such as 60 copper, 40 zinc, are more susceptible than alloys with less zinc. Special brasses which contain other elements behave similarly to the straight zinc brasses. The cracking is usually intergranular, but transcrystalline cracking has been reported, particularly in the beta phase of high zinc brasses.

As compared with the brasses, other commercial copper alloys, as aluminum bronze, tin bronze, silicon bronze and cupronickel show comparatively little tendency to season crack, although failures are known, and sometimes the failures may occur in other than ammoniacal atmospheres. For example, the ASME Boiler Code cautions on the use of silicon bronze in steam above 212 degrees F. Cook²⁴ reported pure copper to be immune to cracking for all practical purposes. Thompson and Tracy⁴⁸ found most additions to copper to cause a rapid increase in susceptibility to cracking, but larger additions of the same elements caused the susceptibility to decrease again.

An acid mercury salt solution is sometimes used as an inspection test to determine the susceptibility of copper alloys to stress corrosion cracking.^{20, 49-52} Metallic mercury is liberated on the surface and penetrates stressed metal intergranularly. This is a different type of attack than stress corrosion cracking, but results are roughly comparable. However, cracking in service has been known to occur in material which has passed the mercury test.

A better but more difficult test involves exposure to a gas phase containing ammonia, air, water vapor and carbon dioxide.^{48, 49} This relates directly to service conditions. For reproducible results the temperature must be controlled and also the composition of the gas phase. With this test there seems to be no threshold stress below which cracking will not occur in time. This probably relates to the fact that some intergranular attack occurred in the absence of stress. This test is particularly suited for experimental studies.

Aluminum Alloys

Pure aluminum is quite resistant to stress corrosion cracking. On the other hand aluminum alloys containing more than 12 percent zinc or more than 6 percent magnesium have cracked in such mild environments as the atmosphere and tap water.^{23, 53}

In aluminum alloys the cracking is intergranular. It is significant that grain boundary constituents have been observed microscopically, and that potential measurements have shown the grain boundary region to be anodic to the grains in solutions known to produce cracking. Attempts have been made to extend these observations to other alloy systems.⁵⁴

In studying the stress-corrosion cracking of aluminum alloys it is customary to use salt solutions containing sodium chloride and hydrogen peroxide. Susceptible alloys crack rapidly under these conditions. Complete immersion, alternate immersion and spray have been used as well as anodic currents.

Magnesium Alloys

Pure magnesium, magnesium casting alloys and magnesium-manganese alloys are relatively resistant to stress-corrosion cracking. On the other hand some magnesium alloys will crack rapidly in the atmosphere and in a variety of corrosives.^{55, 56} The sensitivity to cracking increases with aluminum and zinc content. Minor impurities such as iron may be bad. Additions of lead, tin or cadmium seem to have little effect.

In magnesium alloys the cracking is predominantly transcrystalline. Cold rolled and fully annealed materials are more sensitive than fully precipitated materials. On the more sensitive materials welding increases the possibility of cracking because of high stress and the presence of annealed areas adjacent to the weld. Riveted seams are less prone to cracking. Creep may relieve the stresses in wrought magnesium alloys, particularly those low in aluminum and zinc.

In studying the stress corrosion cracking of magnesium alloys, tests have been made in both inland and marine atmospheres, and in sodium chloride solutions with and without added chromate.²⁰ A wide variety of test specimens has been used.²³ Behavior varied somewhat with the conditions of test. Thus the salt chromate solution was said to correlate well with the exterior test, but not with tests in plain salt solution.

Other Metals and Alloys

Stressed metals are used satisfactorily in many environments. No way is known of predicting behavior in a new environment. A medium which produces cracking of a given alloy may have no effect on other alloys. Thus titanium seems to resist stress corrosion cracking under conditions where stainless steels have failed.⁵⁷

Nickel and nickel alloys are comparatively immune to this disease, but Fraser has reported a number of failures.²³ Stressed Monel has been found to develop both intergranular and transcrystalline cracking in fluosilicic acid. In laboratory tests in moist vapor, U-bend specimens quickly develop transcrystalline cracking, Figure 10.³⁸ Under service conditions the cracking has sometimes been intergranular, Figure 11.

Lead under static tensile stress has been shown to crack intergranularly in lead acetate solution, but not in distilled water.⁵⁸ The impure zinc die castings used many years ago seemed susceptible to intergranular stress corrosion cracking.⁹ It has been said that if the right environment were found, stress-corrosion cracking could be produced in all metals and alloys.

Molten Metals

Often associated with stress corrosion cracking is the attack of molten metals on stressed material.⁵⁸ This is not really stress corrosion cracking, because the attack can be classed as corrosion only by a liberal interpretation of the term. The mercury test for stressed brass is of this type. It seems to be the rule (possibly with exceptions) that there is danger of intergranular penetration by molten metal, provided

tensile stresses are present and provided clean metal surfaces are exposed. Wetting of the surface, interfacial angles and intermetallic compounds may be involved.⁵⁹ Oxide coatings and other surface coatings may be protective. Bending test specimens while immersed in the molten metal is a good way of producing the attack. In the absence of tensile stresses the nature of any attack by molten metals will be general on the surface, instead of intergranular.

Tests for Stress-Corrosion Cracking

A number of tests have already been described. It is important to reproduce the service environment. The stress may be applied in numerous ways. A constant load applied directly, through a lever, or by means of a spring permits accurate measurement of the applied stress. Weights may be hung on specimens so as to produce bending, or the loading may be eccentric. To obtain stresses similar to those present under service conditions, constant deformation is sometimes preferred, with U-bends, C-bends, and modifications being used. Flattened tubes and welded specimens have also been used. With constant deformation, small cracks relieve the stress, and if many small cracks form, growth of cracks may cease. With constant load, cracks increase the stress on the remaining sound metal and hasten failure.

Internal stress may be estimated by mechanical, X-ray, or other methods.⁶⁰⁻⁶² With a suitable setup, applied tensile stress may be measured directly, or from stress-strain curves by means of extensometers or electric strain gages.⁶³ To avoid complications it may be preferable to start with stress-relieved material.⁴³

Correlation between laboratory tests and service performance is difficult to obtain. Exact correlation should not be expected because service conditions are frequently complex. Failure in an accelerated laboratory test does not mean necessarily that failures are to be expected in practice. Experience has shown that generally stress corrosion cracking is not encountered in service unless the tensile stresses present (internal plus applied) are high. Laboratory tests are useful as a means of control, in developing new alloys, and in isolating the specific components of the environment responsible for the cracking.

Prevention of Stress-Corrosion Cracking

The obvious methods of prevention are either to remove the excessive tensile stress or to remove the corrosive. A full anneal and slow cool of the fabricated pressure vessel is a dependable means of preventing stress-corrosion cracking provided applied loads are not excessive. A full anneal is not always permissible because it lowers the properties. It has been found, however, that with suitable temperature and time the loss in strength and hardness can be minimized. An indication of such stress-relief annealing treatments is given in Table 1.^{20, 47} The exact limits of time and temperature depend on the severity of deformation, the composition of the metal and the degree of softening allowable. Manufacturers should be consulted concerning specific alloys and service conditions. The heat treatment should be



Figure 10—Transcrystalline cracking of Monel U-bend specimens exposed to moist fluosilicic acid vapor for 10 days.⁵⁸ X 100.



Figure 11—Intergranular stress corrosion cracking of Monel in fluosilicic acid service. X 100.

Table 1—Suggested Stress Relief Annealing Treatments to Be Followed by Slow Cooling

MATERIAL	General Range of Temperature, °F*	Holding Time, Hr.
Iron and Steel.....	1100-1400	1-3
Stainless Steel.....	1350-1600	1-2
Copper Alloys.....	375- 575	1/2-1
Aluminum Alloys.....	450- 500	1
Magnesium Alloys.....	300- 600	1/4-1
Nickel Alloys.....	1100-1200	1/2-1

* Manufacturers should be consulted for temperature and time for specific alloys and service conditions. The Codes for Unfired Pressure Vessels prescribe certain stress-relieving procedures for steels, and should also be consulted.

followed by slow cooling to safe temperature levels, and care should be taken to insure that no subsequent operation restores the internal stress.

Sometimes stress relief annealing cannot be carried out because it may produce adverse effects on the properties and general corrosion resistance. This may be the case, for example, with some heat-treated aluminum alloys, and with stainless steels which are to be used in an environment where carbide precipitation results in intergranular corrosion. Stress-relief annealing may be impractical under some conditions as when the equipment is large. The procedure may be useless in composite structures where one metal is rigidly attached to other metals having different coefficients of expansion. The so-called low-temperature stress-relieving method³² may have some merit in certain field-erected structures.

Usually complete elimination of internal stresses is not necessary. Changes in the method of manufacture may sufficiently lower the tensile stresses at the surface. Shot peening, tumbling, rolling, swaging, stretching, flexing, bending or straightening between rollers, depend on plastic deformation to decrease dangerous tensile stresses or to convert them into compressive stresses. Compressive stresses in a surface layer may not be a permanent remedy because the layer may be removed by corrosion. Changes in design may distribute the stresses more uniformly, as by increasing the number of supports in large vessels.

Removing or changing the corrosive agent is not as hopeless as it sounds. A reduction in temperature or dilution where possible may suffice.²⁹ A critical constituent may be removed if its presence is known. Inhibitors may sometimes be added as is done to combat caustic embrittlement. In the use of inhibitors care must be taken not to localize the attack and accelerate failure. Paints and protective coatings can be used to prevent the corrosive from contacting the metal. For example, painting magnesium alloys susceptible to stress corrosion cracking has increased their life four or five times. Anodic electrodeposits or thick pore-free cathodic electrodeposits have worked well. Cathodic protection or use of sacrificial anodes which stop the corrosion have stopped the cracking in many experiments. However, hydrogen embrittlement associated with the cathodic current might aggravate the cracking problem in some instances.

A sound method of avoiding cracking is to pick a resistant alloy. Occasionally comparatively small changes in composition may be helpful. Thus, lowering the zinc content of brass or the magnesium content of an aluminum-magnesium alloy might be of benefit. Changes in deoxidation practice, heat treating and other procedures often have some effect on the cracking tendencies. On the other hand substituting one austenitic stainless steel for another has not prevented cracking in sodium chloride, and alloying of steel has been of little help in resisting caustic embrittlement.

Theory of Stress Corrosion Cracking

No universally accepted theory of stress corrosion cracking has been developed, and it is not likely that the same mechanism applies in all cases. The principal theories have been reviewed by Harwood.²¹

The electrochemical theory developed by Dix⁵³ and his co-workers⁵⁴ postulates that intergranular cracking is tied in with the presence of anodic constituents at the grain boundaries. Tensile stresses are pictured as pulling the metal apart at any corrosion crevices and exposing fresh anodic material. Since potential relationships may change in different environments, it helps explain why cracking is observed only in specific corrosive media. It is pointed out that other continuous paths may exist besides at grain boundaries, for example, at slip planes and planes of precipitated constituents. Thus the theory may apply to transcrystalline stress-corrosion cracking. This theory seems well supported in the case

of aluminum alloys and some other metal systems. Support for the theory is found in the fact that an applied potential making the system cathodic has prevented the stress-corrosion cracking of brass, aluminum, stainless steel, and magnesium.²³

The film theory is rather similar but pictures the anodic areas as occurring at points of breakdown of a protective film. Once a notch is formed, tensile stress causes rupturing of protective films, and the exposed metal is anodic and corrodes. Modifications of this theory have been discussed by Evans⁶⁴ with emphasis on the film-forming tendencies at the tip of a crack.

The strain-accelerated decomposition theory postulates that the principal function or stress is to generate precipitation reactions or phase transformations which provide the anodic paths for corrosion.⁶⁵ Corrosion of the newly formed anodic material forms cracks, which concentrate the stress, which accelerates the decomposition and so on. In the case of steel, iron nitride is said to be the precipitated material. In the case of austenitic stainless steels, a martensitic decomposition product is suspected.

The mechanical theory as discussed by Keating⁶⁶ considers crack propagation as purely a function of stress systems tending to tear the metal apart. Electrochemical factors are considered important mainly in the initiation of the crack or crevice. It seems likely that the relative importance of the corrosive and the stress may change as cracking proceeds.

Hydrogen may play a role in some instances of cracking. Zapffe²⁷ insists that attack by hydrogen is responsible for the cracking of steel exposed to caustic with the mechanism being similar to attack by hydrogen at high temperatures.⁸ Cathodic charging with hydrogen accelerated the stress cracking of chromium stainless steel in sodium chloride,⁶⁶ and hydrogen embrittlement may play a part in stress cracking in hydrogen sulfide.³⁹

Other aspects of the problem have been discussed in the literature.^{67,68} Further development of the theory is to be expected as new work is carried out.

Corrosion Fatigue

Fatigue failures of pressure vessels are an obvious hazard. The design engineer usually considers the fatigue characteristics of the materials, and this subject is thoroughly discussed in many places.⁶⁹ The difficulty is that fatigue tests are conducted in air where corrosion is presumably exerting little or no influence. If the metal is exposed to a corrosive environment, fatigue tests in air are almost meaningless.⁷⁰ Under such conditions the failures are a matter of corrosion fatigue which is much more drastic in its action.

It might be expected that exposure to a corrosive environment followed by subsequent fatigue testing would result in lower endurance limits. This has been shown to be the case.⁷¹ The reason is the roughening of the surface by corrosion with resultant notch formation. This type of test however, is not sufficient because the damage is much greater when corrosion goes on at the same time as the repeated stresses. The damage is greater than can be explained by the two factors acting additively.

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For most corrosives, corrosion products and films tend to block or retard the attack or even to cause it to cease completely. Cyclic stresses tend to rupture or render more permeable these protective films. The result is that cyclic stresses accelerate corrosion. As already mentioned the roughening and pitting of the surface by corrosion forms notches which concentrate the stress, and thus accelerate the effect of applied cyclic stresses. These mutually accelerating processes continue until failure occurs by corrosion fatigue.⁷²

In acid solutions where the possibilities of film formation are more remote, the mechanism may be somewhat different.⁷³ The cyclic stresses may produce distorted metal which is more susceptible to corrosion or it may change the area ratios and polarization characteristics of local anodes and cathodes. The formation of disarrayed metal may be important also during corrosion fatigue in neutral solutions.⁷⁴ The disarrayed metal seems more susceptible to corrosion only while it is in process of formation, and is no longer especially susceptible after it has had a chance to settle down. Additional aspects of the situation have been discussed by Evans and Simnad,^{64, 75, 76} with particular emphasis on potentials and the behavior of local anodes and cathodes. In any case the effect of cyclic stress is to increase the corrosion and to cause the corrosion to form deep sharp pits and notches.⁷⁷

Corrosion is the most important factor in corrosion fatigue. This means that test should be run under the actual corrosive conditions to be encountered in service. This is not easy. Some of the problems connected with corrosion testing have been pointed out, and when cyclic fatigue stresses are added to the other test requirements, the problems multiply. All of the factors which influence normal corrosion would be expected to have some effect on corrosion fatigue.⁷⁸ Hence the composition of the corroding medium, the temperature, degree of aeration, and velocity must all be carefully controlled, and the possibilities of galvanic and other effects should be considered.

In addition, corrosion fatigue testing has some complications not present in fatigue testing in air. It is evident that, with sufficient time, corrosion alone will produce failure regardless of applied stress. It follows that in corrosion fatigue there can be no endurance limit. Furthermore since corrosion proceeds with time, the speed of testing has much greater influence than in fatigue. Sufficient time must be allowed for corrosion damage to occur. On the other hand the rate of stress application may control the damage to surface films, the chances of film repair and other factors controlling the acceleration of corrosion. Thus it is necessary to state the maximum repeated stress endured by a metal without failure in a stated number of stress applications under defined conditions of corrosion and stressing. Through common usage this is often called the corrosion fatigue limit.

As a consequence of the considerations above it is clear that corrosion fatigue limits in the literature can rarely be used directly for specific design pur-

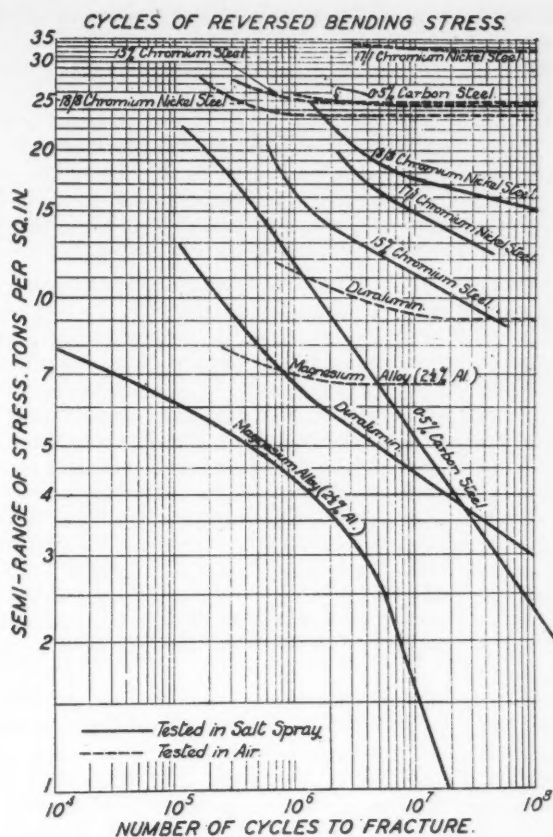


Figure 12—Typical S-N curves in air fatigue and in corrosion fatigue in salt spray.⁸¹

Table 2—Some Corrosion Fatigue Limits^{82, 83}
(Stressed for At Least 10⁷ Cycles at 1450 CPM)

MATERIAL	Tensile Strength, psi	Endurance Limit in Air, psi	Corrosion Fatigue Limit, psi	
			Fresh Water	Brackish Water
Carbon steels, annealed.....	46-103,000	25-42,000	16-23,000	5,000
Carbon steels, hardened.....	66-111,000	35-53,000	19-23,000	7,000
3.5 Ni steel, annealed.....	93,000	49,000	29,000	.....
3.5 Ni steel, hardened.....	125,000	69,000	25,000	.....
5.4 Ni steel, annealed.....	122,000	55,000	21,000	.....
5.4 Ni steel, hardened.....	133,000	66,000	19,000	.....
3.1 Ni, 1.6 Si steel, annealed.....	138,000	65,000	22,000	.....
3.1 Ni, 1.6 Si steel, hardened.....	251,000	108,000	12,000	.....
0.9 Cr, 0.14 V steel, annealed.....	59,000	42,000	22,000	.....
0.9 Cr, 0.14 V steel, hardened.....	161,000	69,000	17,000	.....
14.5 Cr stainless, annealed.....	94,000	52,000	36,000	36,000
14.5 Cr stainless, hardened.....	117,000	53,000	37,000	27,000
17.3 Cr, 8.2 Ni stainless.....	125,000	50,000	50,000	25,000
17.7 Cr, 25.3 Ni stainless.....	115,000	54,000	45,000	34,000
10.9 Cr, 34.7 Ni stainless.....	112,000	57,000	41,000	22,000
Nickel, annealed.....	78,000	33,000	24,000	22,000
Nickel, hardened.....	132,000	51,000	24,000	22,000
Monel, annealed.....	82,000	37,000	26,000	28,000
Monel, hardened.....	127,000	52,000	25,000	28,000
Nickel-copper, 21/78, annealed.....	47,000	19,000	18,000	18,000
Copper, annealed.....	31,000	10,000	10,000	10,000
Copper, hardened.....	47,000	17,000	18,000	18,000
Brass, 62/37 annealed.....	53,000	21,000	18,000	.....
Brass, 62/37 hardened.....	84,000	24,000	18,000	.....
Aluminum, annealed.....	13,000	6,000	.....	2,000
Aluminum, hardened.....	21,000	8,000	5,000	3,000
Aluminum, 1.2 Mn, annealed.....	17,000	7,000	3,000	.....
Aluminum, 1.2 Mn, hardened.....	30,000	11,000	6,000	4,000
Duralumin, annealed.....	33,000	14,000	8,000	7,000
Duralumin, hardened.....	69,000	17,000	8,000	7,000

poses. Judgment and experience are essential in the application of corrosion fatigue data to operational problems. This can be illustrated by some work of

Gould,⁷⁹ where he found that the endurance of steel to cyclic stresses in sea water as measured in a push-pull machine was five times that obtained in the usual rotating beam machine. In the push-pull machine all the anodic areas were exposed to yawning or stretching, whereas in the rotating beam machine only a fraction of the anodic areas were so exposed. This changed the anode-to-cathode area ratio and affected the development of sharp pits. This effect would vary greatly with service conditions.

Corrosion Fatigue Data

Some corrosion fatigue data are given in Figure 12,^{80, 81} Table 2^{82, 83} and Table 3. Additional data in many other corrosives may be found in the literature.

Figure 12 shows some typical *S-N* curves for various materials as obtained in air and in salt spray. The ordinate logarithmically represents the semi-range of stress, and the abscissa logarithmically represents the number of stress cycles to cause failures. Individual points are not shown but there usually is considerable scatter. The curves demonstrate that in air most metals have a very definite fatigue limit, that is a stress-range below which fracture is not expected to occur, however long the action lasts. Under corrosion fatigue conditions no such limit can be determined.

In Table 2 some corrosion fatigue limits are listed after at least 10^7 cycles at 1450 cpm for fresh water and brackish water exposures. This is a common method of expressing the results. The figures are of value in that they give a fair comparison of the corrosion fatigue behavior of metals. Table 3 illustrates another and perhaps better method of comparing data on the corrosion fatigue behavior of metals. It indicates the rapid damage at relatively high frequencies and relatively short periods of time. For example, in a little over one hour's exposure the strength of the high-strength nickel-silicon steel was reduced to 63 percent of its original value.

The important conclusion from the data is that corrosion fatigue properties depend primarily on the corrosion resistance under the test condition. The maximum resistance to corrosion fatigue is exhibited when the alloy is in the best condition to resist corrosion. Other forms of heat treatment and cold work, while affecting the tensile strength and the endurance limit in air, have little or no effect on corrosion fatigue. Thus in Table 2 the high-strength steels have a corrosion fatigue resistance close to that of plain mild steel. Alloying or changes in composition are beneficial only when they confer increased corrosion resistance.

In comparison with the low-alloy steels, the stainless steels showed greatly improved corrosion resistance and much greater corrosion fatigue resistance. The test conditions were favorable to the stainless steels in that the surfaces were polished and the solutions aerated. Under corrosive conditions tending to pit stainless steel the comparisons might be less favorable.

Nonferrous metals when resistant to the environment show favorable

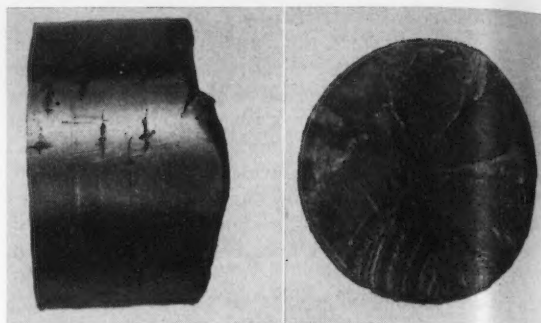


Figure 13—Corrosion fatigue failure of a propeller shaft.⁹ Approx. X 0.8.

corrosion fatigue resistance. Thus Monel with half the endurance limit of steel was so much more resistant to the corrosives that under corrosion fatigue conditions it became a decidedly stronger material in a relatively short time. Hardening treatments had little effect on the corrosion fatigue limits of the nonferrous metals, just as with the steels.

Copper was unique in that some of its corrosion fatigue limits were higher than its endurance limit. This has been attributed to the fact that some corrosion is occurring during fatigue tests in air due to the moisture and oxygen present.⁷⁰ With many metals the ratio of the fatigue limit in air to the fatigue limit in vacuum is close to unity. In the case of copper this ratio is 0.88, in the case of brass 0.79, and in the case of lead 0.45.⁸⁴

It should be emphasized that the data in Table 2 pertain only to the corrosive conditions involved. Changing the environment is likely to change the picture. For example, in unaerated oil well brines containing hydrogen sulfide, low-alloy nickel steels have been markedly superior to unalloyed steels in resisting corrosion fatigue.^{100, 101}

Identification of Corrosion Fatigue

A typical corrosion fatigue failure is shown in Figure 13.⁹ This is part of a propeller shaft which broke in service. General corrosion is slight but deep pits are present. Cracks are visible at many of the pits. The cracks are normal to the direction of the stresses. The presence of many cracks is a common characteristic of corrosion fatigue. These numerous cracks often result in the fracture having a serrated appearance. In fatigue in air there is rarely evidence of more than one crack. Other typical features are the smooth appearance of the fracture and ripple marks showing the point of origin.⁷⁰

Table 3—Corrosion Fatigue Data^{82, 83}

	Tensile Strength, psi	Endurance Limit, psi	Cycles → Days →	Corrosion Fatigue Limits (Fresh Water), psi			
				10 ⁵ 0.047+	10 ⁶ 0.47+	10 ⁷ 4.7+	10 ⁸ 47+
3.1 Ni, 1.6 Si steel	251,000	108,000		68,000	36,000	14,000	12,000
0.9 Cr, 0.14 V steel	161,000	69,000		83,000	48,000	20,000	17,000
Monel	129,000	52,000		86,000	61,000	34,000	21,000
Brass 62/37	84,000	24,000				20,000	18,000
Duralumin	69,000	17,000		30,000	17,000	11,000	8,000

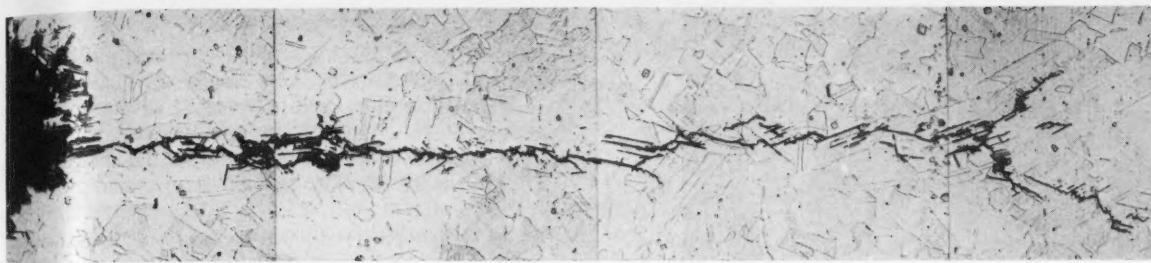


Figure 14—Corrosion fatigue crack in a stainless steel tube. Approx. X 180.

Under the microscope corrosion fatigue cracks generally appear similar to fatigue failures. Figure 14 shows a typical corrosion fatigue failure in a stainless steel tube. There is a pit at the surface, the crack is mainly transcrystalline and shows a marked tendency to follow slip planes. Under other conditions, as with steel in boilers,⁸⁵ corrosion products may fill the cracks and obscure fracture surfaces.

If fatigue failures are transcrystalline, as is the case in most metals, corrosion fatigue cracks are usually transcrystalline also. If fatigue failures are intergranular as in lead, corrosion fatigue cracks are intergranular. However, where the corrosion under stressless conditions or under static stress is intergranular, the corrosion fatigue cracks may be intergranular. Figure 15 shows a corrosion fatigue crack in an Inconel airplane boiler, where the cracks are partly intergranular and partly transcrystalline.⁸⁶ Here precipitation of intergranular carbides at the temperature of service facilitated the intergranular attack. Instances are known where the cracks started out in intergranular fashion and wound up completely transcrystalline. This is interpreted as indicating the predominance of corrosive influences at the start of the attack, and the predominance of fatigue after the attack was well started.

Protection Against Corrosion Fatigue

Noncorrosive and sacrificial metallic coatings suggest themselves, but it is necessary to make tests to be sure what the results will be.⁸⁷ Some coatings may decrease the fatigue strength in air, and still improve the corrosion fatigue limit in some environments. Of course, the benefit of any coating is gone as soon as the coating breaks down.

Cathodic coatings, such as nickel and copper on steel, should be thick enough to remain pore-free. Data have been reported showing that nickel electro-deposits on steel were beneficial under corrosion fatigue conditions in sodium chloride spray.⁸⁸ Chromium plating provided considerable protection to steel in steam.⁸⁹ In the case of composite coatings the behavior is difficult to predict.⁹⁰

Anodic coatings need not be pore-free because they provide sacrificial protection by preventing corrosion. Zinc coatings were discussed by Harvey.⁹¹ In galvanizing, the brittle zinc-iron alloy might favor the inception of cracks, and in electroplating fear has been expressed that there might be hydrogen embrittlement of the steel base. However, hydrogen embrittlement has been found to have no effect on corrosion

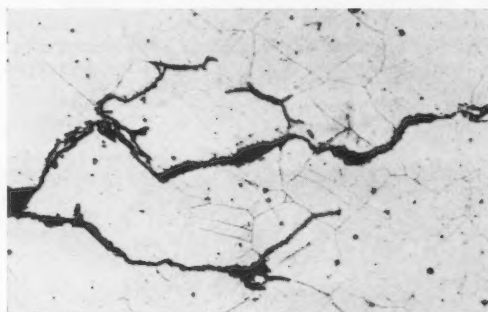


Figure 15—Corrosion fatigue crack in an Inconel airplane boiler, partly intergranular and partly transcrystalline.⁸⁶ X 100.

fatigue where the stressing was within the elastic range.⁹² Metal sprayed coatings of zinc, cadmium and aluminum on steel have been used⁹³ and also paints highly pigmented with zinc.⁷⁸

The corrosion fatigue behavior of coatings is influenced by internal stresses. Tensile stresses in plated coatings seem harmful and compressive stresses beneficial. Nitrided steels exhibit exceptional resistance to fatigue owing to the compressive stresses present. These compressive stresses in nitrided steels have been shown to be beneficial as well under some corrosion fatigue conditions.⁸⁹ Shot peening to produce surface compressive stresses likewise has been shown beneficial in corrosion fatigue tests in sea water and sulfuric acid.⁹⁴ The effects of shot peening, however, are complicated, and in solutions with high alkali content shot peening was harmful under corrosion fatigue conditions apparently because it localized the attack.

Corrosion inhibitors can be helpful in corrosion fatigue, and their effect parallels their influence on normal corrosion. The danger with inhibitors is that they may fail locally, either due to insufficient quantity of inhibitor or to local conditions such as the presence of crevices.⁹⁵ A similar danger exists with the use of an applied cathodic current in that an interruption in the protection might allow a few sharp pits to develop, which would be more harmful than the more general attack in the absence of protection. In hydrochloric acid a cathodic current failed to have much effect on the corrosion fatigue life, probably because the current could not reach the tips of the developing cracks.⁷³



Figure 16—Fatigue crack around a fitting which started at a deep groove formed by corrosion in the crevice on the inside where the fitting joined the tank.

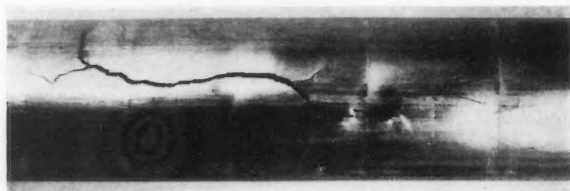


Figure 17—Cracking on outside of a stainless steel tube. Approx. X 0.75

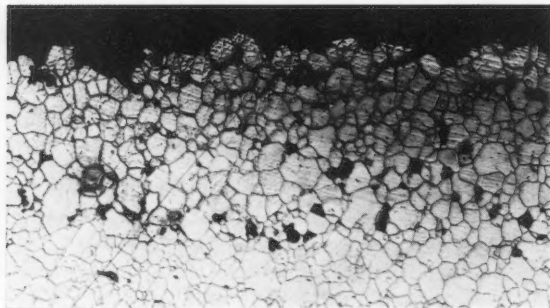


Figure 18—General intergranular attack on inside of tube in Figure 17, which was accelerated locally to produce the cracking.

Local Attack

At the start it was pointed out that local attack by corrosion could form dangerous notches and grooves in pressure vessels. A number of causes for such local attack were listed. Under suitable circumstances such attack might be caused by galvanic corrosion. Such local attack might occur in the crevices formed by reinforcing rings or at crevices around fittings. Such corrosion does not cause cracking itself, but it may lead directly to cracking through its weakening effects. Figure 16 shows a fatigue crack around a fitting in a tank. The crack started in a groove formed by crevice corrosion on the inside. The crevice occurred where the fitting joined the tank. Without this crevice the corrosion behavior would have been satisfactory, and without the notch formed by corrosion the fatigue behavior would have been satisfactory.

Intergranular Attack

Some metals under proper conditions of heat treatment and in suitable environments are susceptible to intergranular corrosion. A number of examples were listed by Rawdon.⁵⁸ This is distinct from stress-corrosion cracking. It depends on the metallurgical conditions of the alloy.⁶⁰ A classic example is the intergranular corrosion of stainless steels which may occur when the temperature or heat treatment is such as to precipitate carbides at the grain boundaries and cause chromium depletion. Such intergranular attack when it occurs is accelerated and localized by tensile stresses. It would be particularly dangerous in pressure vessels and could lead to rapid cracking. The remedy, of course, is to avoid alloys and conditions which produce this kind of attack.

Figure 17 shows a crack on the outside of a stainless steel tube. The crack tends to wander around but it would be difficult to classify it from its superficial appearance. Microexamination showed that the entire inside surface of this tube had suffered severe intergranular attack as illustrated in Figure 18. This general intergranular attack was accelerated locally and led to the cracking. In this case the corrosion and cracking could have been prevented by proper heat treatment of the stainless steel.

Effect of Stress on General Corrosion

There is a widespread belief that static stresses invariably increase the rate of general corrosion. There is little to substantiate so broad a belief. In most instances it appears that the effect of normal amounts of static stress on uniform corrosion are comparatively small. It can be said that no recognized problems exist in this connection. If the metal is of normal quality and the customary factors of safety are employed, the design engineer scarcely needs to concern himself with acceleration of weight loss by corrosion due to static stress.

The expectation of increased corrosion is usually based on the fact that energy may be stored locally in distorted metal, and this should make it less noble. Potential measurements given in the literature are conflicting, but this point has been clarified.⁷⁶ The potential of the freely corroding metal may not change greatly even though the potential of the local anodes on open circuit has shifted in the less noble direction. Furthermore it is well known that relative potential by itself gives no certain indication of corrosion behavior. The electrochemistry of stressed metals has recently been reviewed by Simnad.⁷⁵

The literature contains an extensive but conflicting array of data, opinion and comment on the effect of static stress on uniform corrosion. Some data by the author appear in the *Corrosion Handbook*.⁹ Evans²⁴ has attempted to rationalize the situation, and feels that any effect of cold work on corrosion would be evident only below pH 4. In neutral solutions the rate of corrosion is often controlled by the rate of supply of oxygen, and hence cannot be increased by stress. In accord with this, most examples of stress increasing corrosion are in acid solutions, but even in acids there appears to be no general rule.

Effects of Hydrogen Generated by Corrosion

Many instances of hydrogen attack of steel pressure vessels are recorded in the literature. At high temperatures and pressures the attack is fairly well understood.⁸ It is a matter of hydrogen diffusing into the steel and reacting with carbides and other constituents to form methane and other products. High gas pressure at localized sites within the steel results in fissuring. Severe attack can usually be prevented by alloying with suitable elements to form stable carbides.⁹⁷

At lower temperatures the hydrogen generated by corrosion in aqueous solutions can also cause damage to steel although the nature of the attack is different. Atomic hydrogen formed by the corrosion reaction diffuses through steel quite readily. Dissociated hydrogen can also leave the steel. However, if the rate at which hydrogen enters steel is greater than that at which it leaves, internal pressures build up owing to the accumulation of molecular hydrogen in rifts or pockets, and cause embrittlement, blistering and fissuring.^{8,99} These effects obviously weaken the steel. An instance has been recorded where they were responsible for the head blowing off a pressure vessel.⁸⁰

The factors which control the rate at which hydrogen enters steel are not well understood. Many corrosion reactions are harmless even though plenty of hydrogen is generated. It seems certain that the surface of the steel must actively promote the acceptance of atomic hydrogen rather than catalyze the association of atoms to molecules of hydrogen gas. The presence of sulfur, arsenic, selenium, tellurium, antimony and phosphorus promote hydrogen absorption. Once hydrogen accumulates in steel it is bound to produce embrittlement and loss of ductility, which shows up as cracking on bending. Blistering and fissuring may depend in part at least on the quality of the steel.⁹⁹

Hydrogen sulfide is the bad actor in promoting hydrogen damage in many instances. However, iron sulfide corrosion products seem to be protective and slow down the corrosion and entrance of hydrogen. The co-presence of acidic material such as acetic or formic acid increases the hydrogen penetration probably by removing the protective iron sulfide. In alkaline solution cyanide may react with and remove the iron sulfide and lead to continued activity.⁹⁹ This tie-in of hydrogen sulfide and cyanide is reminiscent of some so-called stress corrosion cracking failures,^{86, 27} and raises the question of how far hydrogen embrittlement may be involved.

It has definitely been shown that charging with hydrogen accelerated the stress corrosion cracking of 13 percent chromium steel in sodium chloride.⁸⁶ It also seems likely that hydrogen played a part in the cracking of steel in a high pressure gas condensate well containing hydrogen sulfide and carbon dioxide.⁹⁹ The whole subject of the damage which can be caused to pressure vessels by hydrogen generated by aqueous corrosion needs further study. This is particularly true where the effects of hydrogen may be in combination with other phenomena such as stress-corrosion cracking.

Fields for Future Research

Economics make it no longer acceptable to hide ignorance by ample overdesign to take care of the unknown in corrosion. Therefore it becomes important to learn more about corrosion theory and corrosion mitigation.

In neutral solutions the corrosion of iron is controlled largely by the amount of oxygen available. Small changes in composition, type of heat treatment, surface preparation and internal stresses have little or no effect on over-all weight loss. However, such factors can localize the attack and promote pitting or cracking. This aspect needs further study. Perhaps one way of doing this is to study the electrochemistry involved, to determine the potentials of local anodes and cathodes, the area ratios and the polarization curves. Similar remarks apply to other alloy systems as well as iron and steel.

In acid solutions hydrogen evolution is the major cathode reaction and probably controls the corrosion. Here the behavior of the minute cathodes on the metal surface becomes dominant. More needs to be known about hydrogen overvoltage, and the effects of surface finish, inclusions, alloying elements, surface films and corrosion products. What determines whether the hydrogen will enter the metal or be evolved as a gas?

At present corrosion is prevented by cathodic protection, by metal coatings, by organic coatings, by inhibitors, by treatment of the environment and by the use of alloys. But, as indicated in the text, the application of these methods to the prevention of cracking needs further study.

Cathodic protection applied too late, for example, may not stop the growth of cracks already existing. Underprotection may actually localize the attack and hasten a failure due to cracking. Overprotection with too much current may cause hydrogen embrittlement and resultant complications. Some easy and satisfactory means of establishing when complete cathodic protection is attained is urgently needed. Also needed are quantitative data relating the corrosion factors of the environment (temperature, aeration, velocity, pH, dissolved salts, galvanic couples, time, etc.) to the minimum current for total protection. Substantially similar remarks could be made for the use of inhibitors. A better understanding of the mechanism of their action and of their proper application is needed.

Returning specifically to stress-corrosion cracking, there is no way of knowing whether an alloy will resist cracking in a given environment except by trial and error. It is not known why some environments produce cracking and others do not. The theory and mechanism of stress corrosion cracking needs further development with detailed knowledge of the influence of internal structure, the magnitude and distribution of stresses, and the influence of the environment. How do minor constituents in the environment act as accelerators or as inhibitors of cracking? What determines whether the path of the crack will be intergranular or transcrystalline? Also the roles, if any, of hydrogen in stress corrosion cracking should

be tied down. More needs to be known about the effect of changes in composition, heat treatment and structure of metals and alloys. It is not yet certain whether a susceptible alloy can be improved, purified or modified to make it acceptable under some conditions.

With reference to corrosion fatigue much more data are needed under actual service conditions. Corrosion fatigue limits vary with the corrosive environment, but with a sufficient background of information it should be possible to make intelligent appraisals concerning behavior in new environments. Quantitative data are needed relating corrosion fatigue limits to the corrosive factors of the environment, such as temperature, aeration, velocity, pH, etc. More information is needed also on the various protective measures which have been suggested. The theory needs further development particularly as to mechanism by which stress accelerates corrosion. Measurements of the potentials of local anodes and cathodes, area ratios and polarization curves would be elucidating.

The factors which control the entrance of hydrogen into a metal are not well understood. Just how the hydrogen behaves after it gets in the metal is also not clear, although it is certain that its effects can be damaging and can promote cracking. This whole subject of hydrogen damage in aqueous solutions needs further study, particularly where it ties in with cracking of pressure vessels.

References

- Wesley, W. A., Copson, H. R., and LaQue, F. L., "Some Consequences of the Graphite Corrosion of Cast Iron," *Metals & Alloys*, **7**, 325 (1936).
- Colegate, G. T., "Dezincification," *Metal Ind.*, **73**, 483-485, 507-509 (1948).
- Evans, U. R., *Metallic Corrosion Passivity and Protection*, Longmans, Green & Co., New York (1948).
- McKay, R. J., "Corrosion by Electrolytic Concentration Cells," *Trans. Am. Electrochem. Soc.*, **41**, 201 (1922).
- Copson, H. R., "The Effects of Velocity on Corrosion by Water," *Ind. Eng. Chem.*, **44**, 1745 (1952).
- Wyche, E. H., Voigt, L. R., and LaQue, F. L., "Corrosion in Crevices," *Trans. Electrochem. Soc.*, **89**, 149 (1946).
- LaQue, F. L., and Cox, G. L., "Some Observations on the Potentials of Metals and Alloys in Sea Water," *Proc. Am. Soc. Testing Materials*, **40**, 670 (1940).
- Schuyten, J., "Hydrogen Attack on Metals at High Temperatures and Pressures," *Corrosion and Material Protect.*, **4**, No. 5, 13 (1947).
- Corrosion Handbook*, John Wiley & Sons, New York (1948).
- McKay, R. J., and Worthington, R., *Corrosion Resistance of Metals and Alloys*, Reinhold Publishing Corp., New York (1936).
- Speller, F. N., *Corrosion, Causes, and Prevention*, McGraw-Hill Book Co., New York (1935).
- LaQue, F. L., and Knapp, B. B., "Planning and Interpreting Corrosion Tests," *Corrosion and Material Protect.*, **2**, No. 1, 17 (1945).
- Wachter, A., and Treseder, R. S., "Corrosion Testing Evaluation of Metals for Process Equipment," *Chem. Eng. Prog.*, **43**, 315 (1947).
- LaQue, F. L., Marburg Lecture, "Corrosion Testing," Am. Soc. Testing Mats. (1951).
- Hieronymous, T. G., "Disadvantages of Dissimilar Metals in Equipment," *Corrosion*, **2**, 163 (1946).
- Mears, R. B., and Brown, R. H., "Designing to Prevent Corrosion," *Ibid.*, **3**, 97 (1947).
- Fontana, M. G., "Corrosion," *Ind. Eng. Chem.*, **40**, No. 5, 95A (May 1948).
- Colegate, G. T., "Corrosion Prevention, Influence of Correct Design of Metallic Surfaces," *Metal Ind.*, **74**, 123, 151 (1949).
- Reinhart, F. M., "Corrosion Factors in Design," *Prod. Eng.*, **22**, 101 (1951).
- Metals Handbook*, Am. Soc. Metals, Cleveland (1948).
- Harwood, J. J., "The Influence of Stress on Corrosion," *Corrosion*, **6**, 249, 290 (1950).
- Symposium on Corrosion Cracking, *Proc. Am. Soc. Testing Materials*, **18**, II (1918).
- Symposium on Stress Corrosion Cracking of Metals, Am. Soc. Testing Materials and Am. Inst. Min. Met. Eng., 1944.
- Symposium on Internal Stresses in Metals and Alloys, The Institute of Metals, London, 1948.
- Schroeder, W. C., and Berk, A. A., *Inter-crystalline Cracking of Boiler Steel and Its Prevention*, U. S. Dept. Int. Bur. Mines, Bull. 433 (1941).
- Straub, F. G., *Embrittlement in Boilers*, University of Illinois, Engineering Experiment Sta. Bull. No. 216 (1930).
- Zapffe, C. A., "Boiler Embrittlement," *Trans. Am. Soc. Mech. Eng.*, **66**, 81 (1944).
- Berk, A. A., and Waldeck, W. F., "Caustic Danger Zone," *Chem. Eng.*, **57**, No. 6, 235 (1950).
- Schmidt, H. W., Gegner, P. J., Heinemann, G., Pogacz, C. F., Wyche E. H., "Stress Corrosion Cracking in Alkaline Solutions," *Corrosion*, **7**, 295 (1951).
- "Field Test for Tendency of Boiler Water to Cause Embrittlement Cracking of Steel," Tentative Method D 807-46T, Am. Soc. Testing Materials Standards, III-A, 1029, 1946.
- Wilton, H. M., "Caustic Cracking of Welded Steel Plate," *Metal Prog.*, **52**, 803 (1947).
- Greene, T. H., and Holzbaur, A. A., "Controlled Low-Temperature Stress Relieving," *The Welding Journal*, **25**, Research Suppl., 171-s (1946).
- Jones, J. A., "Inter-crystalline Cracking of Mild Steel in Salt Solutions," *Trans. Faraday Soc.*, **17**, 102 (1921).
- Pollard, R. E., "Stress Corrosion Tests of Bridge Cable Wire," *Jnl. Research Natl. Bur. Standards*, **33**, 201 (1944).
- Houdremont, E., Bennek, H., and Wentrip, H., "Investigation of and Elimination of Inter-crystalline Corrosion of Steel," *Stahl u. Eisen*, **60**, 757, 791 (1940).
- Buchholtz, H., and Pusch, R., "An Investigation of the Trans-crystalline Stress-Corrosion Cracking of Steel," *Ibid.*, **62**, 21 (1942).
- Gifkins, R. C., and Rees, W. P., "Stress Corrosion Cracking in Alloy Steel Gas Cylinders," *Metal Treatment*, **13**, No. 5, 109 (1948).
- Cheng, C. F., International Nickel Co., unpublished data.
- Vollmer, L. W., "Sulfide Cracking of Steel," *Canadian Mining and Metallurgical Bull.*, February 1952 [*Trans.*, **13**, 89 (1952)], and *Corrosion*, **8**, 326 (1952).
- "Cracking of Welded Steel Gas Mains," *J. Iron Steel Inst.*, **157**, 136 (1947).
- Rocha, H. J., "Stress Corrosion Cracking of Austenitic Alloys," *Stahl u. Eisen*, **62**, 1091 (1942).
- Nathorst, H., *Stress Corrosion Cracking of Stainless Steels*, Welding Research Council Bull. Ser., No. 6, New York (1950).
- Scheil, M., Zmeskal, O., Waber, J., and Stockhausen, F., "First Report on Stress Corrosion Cracking of Stainless Steels in Chloride Solutions," *The Welding Journal*, **22**, Research Suppl. 493-s (1943).
- Hodge, J. C., and Miller, J. L., "Stress Corrosion Cracking of Austenitic Chromium-Nickel Steels and Its Industrial Implications," *Trans. Am. Soc. Met.*, **28**, 25 (1940).
- "Bibliography on Season Cracking," *Proc. Am. Soc. Testing Materials*, **41**, 918 (1941).
- Croft, H. P., and Sachs, G., "Season Cracking of Brass," *Iron Age*, **151**, No. 10, 47 and No. 11, 62 (1943).
- Sachs, G., "Corrosion Cracking, A Correlated Abstract," *Ibid.*, **146**, No. 14, 21 (1940).
- Thompson, D. H., and Tracy, A. W., "Influence of Composition on Stress Corrosion Cracking of Some Copper-Base Alloys," *Jnl. Metals*, **1**, 100 (1949).
- Morris, A., "Stress Corrosion Cracking of Annealed Brasses," *Trans. Am. Inst. Min. Met. Eng.*, **89**, 256 (1930).
- Rosenthal, H., and Jameson, A. L., "Mercury Cracking Test, Procedure and Control," *Proc. Am. Soc. Testing Materials*, **41**, 897, 905, 927 (1941).
- Rawdon, H. S., "The Use of Mercury Solutions for Predicting Season Cracking of Brass," *Ibid.*, **18**, II, 189 (1918).
- Gesser, H., "The 'Season Cracking' Test for Cartridge Brass," *Metals & Alloys*, **16**, 238 (1942).
- Dix, E. H., Jr., "Acceleration of the Rate of Corrosion by High Constant Stresses," *Trans. Am. Inst. Min. Met. Eng.*, **137**, 11 (1940).
- Mears, R. B., and Brown, R. H., "Causes of Corrosion Currents," *Ind. Eng. Chem.*, **33**, 1001 (1941).
- Beck, A., *The Technology of Magnesium and Its Alloys*, F. A. Hughes and Co., London, 2nd ed. (1941).

56. Perryman, E. C. W., "Stress Corrosion Cracking of Magnesium Alloys," *J. Inst. Metals*, **78**, 621, 642 (1951).
57. Uhlig, H. H., and Cobb, J. R., "Titanium Resists Stress Corrosion," *Metal Prog.*, **59**, 816 (1951).
58. Rawdon, H. S., "The Intercrystalline Corrosion of Metals," *Ind. Eng. Chem.*, **19**, 613 (1927).
59. Robertson, W. D., "Metallurgical Mechanism for Mercury Stress Cracking of Copper Alloys," *J. Metals*, **3**, 1190 (1951).
60. Barrett, C. S., "Internal Stresses," *Metals & Alloys*, **5**, 131, 154, 170, 196, 224 (1934).
61. Wilkins, C. A., "Internal Stress of Metals," *Metallurgia*, **27**, 115 (1943).
62. Sachs, G., and Espy, G., "A New Method for Determination of Stress Distribution in Thin Walled Tubing," *Trans. Am. Inst. Min. Met. Eng.*, **147**, 348 (1942).
63. Dobie, W. B., and Isaac, P. C. G., *Electric Resistance Strain Gauges*, English Univ. Press Ltd, London (1948).
64. Evans, U. R., "Stress Corrosion, Its Relation to Other Types of Corrosion," *Corrosion*, **7**, 283 (1951).
65. Waber, J. T., McDonald, H. J., and Longtin, B., "Theory of Stress Corrosion Cracking of Mild Steel in Nitrate Solutions," *Trans. Electrochem. Soc.*, **87**, 209 (1945).
66. Uhlig, H. H., "Action of Corrosion and Stress on 13 Chromium Stainless Steel," *Metal Prog.*, **57**, 486 (1950).
67. Robertson, W. D., and Uhlig, H. H., "An Observation on Corrosion Cracking without Stress," *J. Appl. Phys.*, **19**, 864 (1948).
68. "Stress Corrosion in Materials," *Materials & Methods*, **27**, 107 (1948).
69. Feltham, P., "Fatigue in Metals, A Critical Survey of Recent Research and Theories," *Iron and Steel*, **21**, 431 (1948).
70. Gough, H. J., "Corrosion Fatigue of Metals," *J. Inst. Met.*, **49**, No. 2, 17 (1932).
71. McAdam, D. J., Jr., and Clyne, R. W., "Influence of Chemically and Mechanically Formed Notches on Fatigue of Metals," *J. Research Natl. Bur. Standards*, **13**, 527 (1934).
72. Thum, A., and Ochs, H., "Corrosion Fatigue Strength," *Korrosion u. Metallschutz*, **13**, 380 (1937).
73. Simnad, M. T., and Evans, U. R., "The Mechanism of Corrosion Fatigue in Acid Solutions," *J. Iron Steel Inst.*, **156**, 531 (1947).
74. Whitwham, D., and Evans, U. R., "Corrosion Fatigue: The Influence of Disarrayed Metal," *Ibid.*, **165**, 72 (1950).
75. Simnad, M. T., "A Review of the Electrochemistry of Stressed Metals," *J. Electrochem. Soc.*, **97**, 31c (1950).
76. Simnad, M. T., and Evans, U. R., "The Influence of Stress on the Electrode Potential and Polarization of Steel in Acid Solutions," *Trans. Faraday Soc.*, **46**, 175 (1950).
77. McAdam, D. J., and Geil, G. W., "Influence of Cyclic Stress on Corrosion Pitting of Steels in Fresh Water, and Influence of Stress Corrosion on Fatigue Limit," *J. Research Nat. Bur. Standards*, **24**, 685 (1940).
78. Huddle, A. U., and Evans, U. R., "Some Measurements of Corrosion Fatigue Made With a New Feeding Arrangement," *J. Iron Steel Inst.*, **149**, 104 (1944).
79. Gould, A. J., "Corrosion Fatigue of Steel Under Asymmetric Stress in Sea Water," *Ibid.*, **161**, 11 (1949).
80. Gould, A. J., "Corrosion Fatigue of Metals. A Critical Survey," *Iron and Steel*, **24**, 7 (1951).
81. Gough, H. J., and Sopwith, D. G., "Some Comparative Corrosion Fatigue Tests Employing Two Types of Stressing Action," *J. Iron Steel Inst.*, **127**, No. 1, 301 (1933).
82. McAdam, D. J., Jr., "Corrosion Fatigue of Metals as Affected by Chemical Composition, Heat Treatment and Cold Working," *Trans. Am. Soc. Steel Treating*, **11**, 355 (1927).
83. McAdam, D. J., Jr., "Corrosion Fatigue of Non-Ferrous Metals," *Proc. Am. Soc. Testing Materials*, **27**, II, 102 (1927).
84. Moore, H. F., "Corrosion Fatigue of Metals," *Metals Handbook*, Am. Soc. Metals, p. 150, 1939 edition.
85. Boetcher, H. M., "Cracking and Embrittlement in Boilers," *Mech. Eng.*, **66**, 593 (1944).
86. Skinner, E. N., International Nickel Co., Unpublished data.
87. Sopwith, D. G., and Gough, H. J., "The Effect of Protective Coatings on Corrosion Fatigue Resistance of Steel," *J. Iron Steel Inst.*, **135**, 315 (1937).
88. Wilson, R. E., "Industrial Electrodeposition. Quality of Adhesion. Testing of Deposits," *Met. Ind.*, **72**, 211 (1948).
89. Fuller, T. S., "Endurance Properties of Some Well-Known Steels in Steam," *Trans. Am. Soc. Steel Treating*, **19**, 97 (1931).
90. Herschmann, H. K., and Thomas, C., "Fatigue Characteristics of Electroformed Steels with and without Iron Backing," *J. Research Nat. Bur. Standards*, **43**, 477 (1949).
91. Harvey, W. E., "Zinc as a Protective Coating Against Corrosion-Fatigue of Steel," *Metals and Alloys*, **1**, 458 (1930).
92. Stuart, N., and Evans, U. R., "The Effect of Zinc on the Corrosion Fatigue of Steel," *J. Iron Steel Inst.*, **147**, 131 (1943).
93. *Prevention of Fatigue of Metals*, Battelle Memorial Institute, John Wiley & Sons, New York (1941).
94. Gould, A. J., and Evans, U. R., "The Effect of Shot-Peening on Corrosion Fatigue of High-Carbon Steel," *J. Iron Steel Inst.*, **160**, 164 (1948).
95. Fink, C. G., Turner, W. D., and Paul, G. T., "Zinc Yellow in the Inhibition of Corrosion Fatigue of Steel in Sodium Chloride Solutions," *Trans. Electrochem. Soc.*, **83**, 377 (1943).
96. Robertson, W. D., "The Effect of Tensile and Compressive Stresses on the Corrosion of an Aluminum Alloy," *Trans. Am. Inst. Min. Met. Eng.*, **175**, 428 (1948).
97. Nelson, G. A., "Metals for High-Pressure Hydrogenation Plants," *Trans. Am. Soc. Mech. Eng.*, **73**, No. 2, 205 (1951).
98. Bartz, M. H., and Rawlins, C. E., "Effects of Hydrogen Generated by Corrosion of Steel," *Corrosion*, **4**, 187 (1948).
99. Effinger, R. T., Renquist, M. L., Wachter, A., and Wilson, J. G., "How Hydrogen Attacks and Damages Steel in Refinery Equipment," *Oil and Gas J.*, **50**, No. 2, 99 (1951).
100. Wescott, B. B., and Bowers, C. N., "Economical Selection of Sucker Rods," *Trans. A. Inst. Min. Met. Eng.*, **114**, 177 (1935).
101. Wescott, B. B., "Fatigue and Corrosion Fatigue of Steels," *Mech. Eng.*, **60**, 813 (1938).

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- TP-5C Stress Corrosion Cracking in Alkaline Solutions. (Pub. 51-3) Per copy, \$5.00.
- TP-6G First Interim Report on Recommended Practices for Surface Preparation of Steel. (Pub. 50-5) Per copy, \$5.00.
- TP-6G Second Interim Report on Surface Preparation of Steels for Organic and Other Coatings. (Pub. 53-1) Per copy, \$1; five or more copies to one address, per copy \$5.00.
- TP-12 Report on Electrical Grounding Practices. Per copy \$5.00.
- TP-19 Corrosive Effects of Deicing Salts—A Progress Report by Technical Practices Committee 19. Corrosion, January, 1954, issue. NACE members \$5.50; Non-members \$1 per copy.

● REPRINTS

- Cathodic Protection and Pipe Lines**
Mitigation of Corrosion on City Gas Distribution Systems by A. D. Simpson, Jr. .50
- Paints and Coatings**
Gasoline Resistant Tank Coatings by W. W. Cranmer..... .50
- Tests, Properties of Corrosion Preventive Lubricants for Lead Sheathed Cables in Underground Ducts—A Discussion by Howard S. Phelps and Frank Kahn..... .50**
- Petroleum Production and Storage**
Corrosion in Condensate and in High Pressure Sweet Oil Wells by R. C. Buchan... .50
- Miscellaneous**
Resistance of Aluminum Alloys to Weathering by C. J. Walton, D. O. Sprowls and J. A. Nock, Jr., and Resistance of Aluminum Alloys to Contaminated Atmospheres by W. W. Binger, R. H. Wagner and R. H. Brown..... .50
- Causes of Corrosion in Airplanes and Methods of Prevention by N. H. Simpson... .50
- Salt Spray Testing Bibliography by Lorraine Voight..... .50
- The Cost of Corrosion to the United States by H. H. Uhlig..... .50
- Why Metals Corrode by H. H. Uhlig..... .50
- Corrosion Control by Magic—It's Wonderful by H. H. Uhlig..... .50
- Index to Corrosion, Volume 8..... .50

REPRINT

Publication 53-1

Surface Preparation Of Steels For Organic and Other Protective Coatings

● Second Interim Report of NACE Technical Practices Sub-Committee 6-G on Surface Preparation for Organic Coatings.

This report itemizes the various procedures used to prepare steels for the application of protective coatings. Recommendations as to procedures, standards, safety measures are given. This second report by NACE TP-6G is the culmination of many months of work by committee members. The report has been carefully prepared and checked by committee members with long experience in the coatings application field.

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- 1947—January, March, June, July, September, November
- 1948—January, February, May, June, July, August, December
- 1949—January, February, June, July, August, September, October
- 1950—January, February, April, May
- 1951—January, February, March, October
- 1952—March

Indices to Corrosion technical literature have been published as follows:

- 5-Year Index, 1945-49 inclusive and Index to Vol. 6, 1950..... December, 1950
- Index to Vol. 7..... December, 1951
- Index to Vol. 8..... December, 1952
- Index to Vol. 9..... December, 1953

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HOUSTON

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TEXAS

Topic of the Month

Asbestos Resin Compositions

in the Chemical Industry

By P. L. McWHORTER*



Figure 1

IN THE chemical industry equipment constructed of a product with the trade name Haveg has been in use for more than twenty years. The best known formulations are those which consist of an inert fibrous base, which is bonded with chemically resistant and heat stable plastic.

The inert fibrous base employed in Haveg grades 41 and 60 consists of selected types of asbestos which have been digested with acid, washed and dried. As a result of this treatment the fibers have become inert to further chemical action. These fibers are then mixed with an approximately equal weight of resin and the result is a clay-like mass which is capable of holding its shape when formed in open molds. These loaded molds are placed in autoclaves and heated by means of circulating air while under pressure. The heated air is controlled to a complex temperature cycle in order to develop all the potential strength and resistance of the material. In the process of heating the soft mixture hardens and becomes strong and tough.

The hardened material is removed from the molds and the next steps in the fabricating process are taken. These may consist merely of machining with carbide alloy tools used for cutting its hard and wear-resistant surface. There need be no concern over retaining the original surfaces for any reason because the Haveg material is chemically resistant throughout and no impregnation is necessary.

Succeeding fabrication steps may require the joining of previously hardened pieces. These joints are made by connecting the hard surfaces with bridges of soft unbaked asbestos resin mixture. These articles are then placed in the autoclaves and after having been given the same heat and pressure treatment which the parts originally received, the assembly becomes a homogeneous unit. In this manner separately fabricated outlets of any type are placed in any part of a previously fabricated tank, or baffles or overflows are added, or other desired changes are made.

Two major grades of Haveg are distinguished by the use of different types of resin to bond the inert asbestos. Haveg 41 is made with a selected phenol-

formaldehyde type of resin, and Haveg 60 employs a furane type of resin. Haveg 41 is resistant to acids of most types, as well as to practically all salts and many solvents. Haveg 60 is quite resistant to most acids, is fully resistant to alkalis, to practically all salts and to a very wide range of solvents. Neither type is suitable for use with strong oxidizing acids, such as nitric or chromic. Both are recommended for service continuously at temperatures as high as 265° F (130° C).

Versatility of the Haveg process permits the manufacture of many different types of chemical process equipment, ranging from large installations of jointed units to small articles requiring a substantial amount of precision in manufacture. An example of the large sectional type installation is that of sheet steel pickling units of more than 100 feet in length. These units are designed to handle strong, hot sulfuric acid which removes the scale from the steel. Single units which are homogeneous, without joints of any sort, are made in the form of tanks, for example, as large as ten feet in diameter and twelve feet in height. Duct and fittings ranging from large diameters to handle great volumes of fumes down to small sizes are regularly built. Housings, impellers and other parts for pumps intended for use with highly corrosive solutions are provided for leading manufacturers. Pipe and fittings ranging in size from twelve inch ID to one-half inch ID are in use in great volume. Valves for all sizes of pipe are furnished as required, for example the familiar flexible diaphragm type shown in Figure 1, which may be obtained with any of the variety of diaphragms available to handle a range of corrosion conditions.

A demonstration of the utility and versatility of these asbestos resin compositions is given in the plants which have been built by the Federal government for the production of magnesium. In these plants magnesium chloride is electrolyzed to form molten metallic magnesium and chlorine gas which is evolved at extremely high temperatures. This hot chlorine gas is carried from the cells in Haveg fume duct lines which have been provided with ceramic inserts for a certain distance from the cell until the temperature has fallen to the point that the Haveg will not be charred on direct contact with the gas.

* Technical Director, Haveg Corp., Newark, Del.

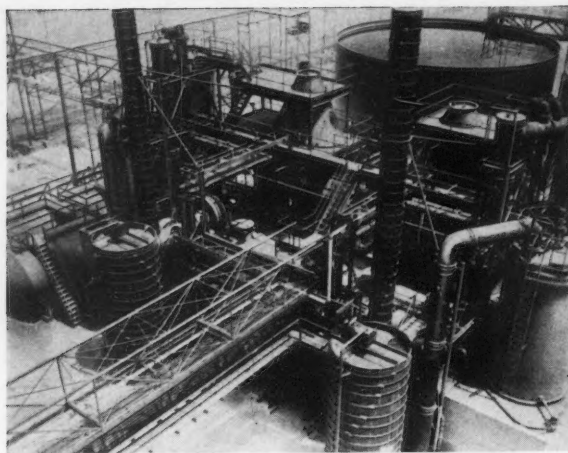


Figure 2

These ducts carry the hot chlorine gas to burners, where the combustion is that of the chlorine with hydrogen, to produce hydrogen chloride or anhydrous hydrochloric acid. This hydrochloric acid is handled in Haveg lines to the point where it is used to dissolve magnesium hydroxide which had been made from sea water. The magnesium chloride obtained from this operation is then electrolyzed and the cycle is repeated. Figure 2 shows the Haveg duct lines, the chlorine burner and associated equipment employed in one of these units.

Another example of the utility of these asbestos resin compositions is that of the plant which is used for the preparation of the inert fibers themselves. This plant, which is shown in Figure 3, consists of Haveg digesters, in which the selected asbestos is treated with circulated boiling strong hydrochloric

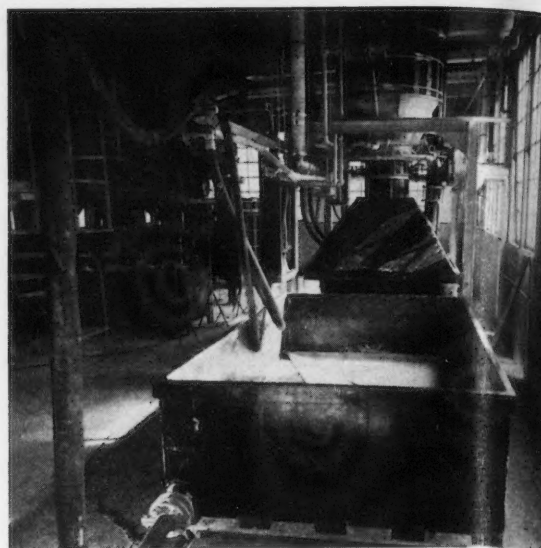


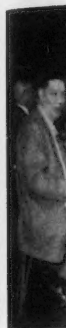
Figure 3

acid. Steam heated tantalum thimbles are used to boil the hydrochloric acid and a Haveg heat exchanger unit, employing carbon tubes for heat transfer, is used to condense and reflux the acid vapors. Haveg duct lines terminating in obnoxious vapor condensers constructed of Haveg, are used with the digesters. Associated with the unit are filters, pumps, pipe lines, diaphragm valves, steam actuated vacuum jets, acid storage tanks and mixing tanks, all of Haveg construction. These units have been in regular operation on a 24-hour-per-day schedule for more than twelve years. Replacement over this period has been limited to a few of mechanical nature, such as pump parts, valve diaphragms and the like.

Statement of Policy on Publication of Technical Papers

In instances where preprints are available, permission will be granted to other journals to publish reviews, condensations, or abstracts prior to publication of the complete paper in *CORROSION* provided these reviews, condensations, or abstracts do not exceed one-third of the total contents of the original paper and provided acknowledgment is given the previous presentation of the paper before an NACE group. In those cases when preprints are not available the representative of a publication is

invited to attend the technical sessions and to make notes to supplement the abstracts supplied by the Central Office to prepare reviews, condensations, or abstracts to be used in the manner described above. An opportunity will be provided at National Meetings for trade press representatives to check notes against the available original papers. As before, permission to publish the entire paper will be withheld prior either to publication of the paper in *CORROSION* or decision not to publish the paper in *CORROSION*.

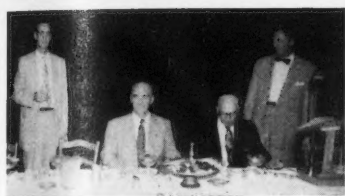
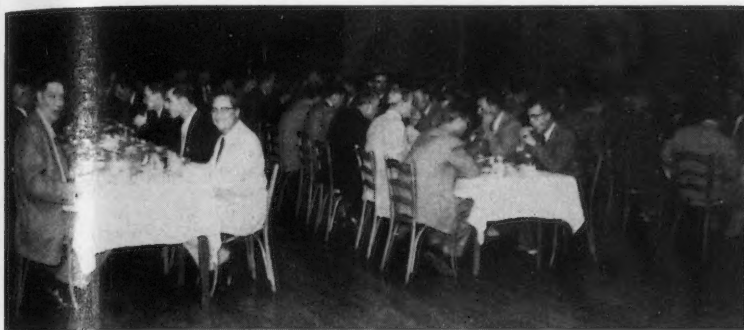


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NACE News



FRIENDS OF BERRY CAMPBELL who gathered at College Inn, Houston, on the night of February 26 enjoyed an evening of good fellowship as a tribute to A. B. Campbell, executive secretary of the National Association of Corrosion Engineers. Above is a view of the group as dinner started. At left standing are, in order, Gordon L. Doremus; seated, Russell Brannon and A. B. Campbell and standing, Charles G. Gribble, Jr., who acted as master of ceremonies.

Friends of A. B. Campbell Honor Him at Houston Banquet During Engineers' Week

47 at Denver Hear Bryan Patterson

Forty-seven members and guests attending the Rocky Mountain Section meeting February 19, in Denver, Colorado, heard Bryan Patterson, Hill-Hubbell Company, speak on the subject of "Corrosion Prevention, Underground." As an addition to the technical portion of the program, the motion picture "Corrosion in Action" produced by the International Nickel Company, Inc. was shown.

Wayne H. Schultz, Dearborn Chemical Company, Denver, Colorado, Karl S. Hagius, Colorado Interstate Gas Company, Colorado Springs, Colorado, and John F. Fugazzi, Public Service Company of Colorado, Denver, Colorado, were formally installed as chairman, vice-chairman and secretary treasurer respectively for 1954. They had been serving as temporary officers prior to this meeting.

Henry K. Becker, Wyco Pipe Line Company, Denver, Colorado, was elected to serve as section trustee; W. R. Trevithick, Mountain States Telephone and Telegraph Company, Denver and L. W. Hartkemeier, Colorado School of Mines, Denver, were elected to serve as Chairman of Underground Corrosion Committee and Chairman of Educational Committee, respectively.

The next meeting scheduled for the Rocky Mountain Section is on May 14, 1954.

In conjunction with the celebration of National Engineer's Week, approximately 100 friends of A. B. Campbell, executive secretary of the National Association of Corrosion Engineers honored him for his services to the field of engineering at a banquet in the Varsity Room of the College Inn, Houston, Feb. 25.

Some were present at the banquet from as far away as New Jersey. Many expressed their personal appreciation of Mr. Campbell's work in the field of engineering. Charles G. Gribble, Jr., who acted as master of ceremonies read teletgrams and other messages from Mr. Campbell's friends from all over the United States and Canada. It was especially remarkable to see so many teletgrams from local sections of NACE.

As a token of appreciation the group presented Mr. Campbell a set of nine matched irons and a bag cart for his golfing pleasure. All present signed a scroll which was presented to Mr. Campbell.

LaQue Heard by 65

Sixty-five members and guests of the Toronto, Hamilton-Niagara and Western New York Sections met in a joint meeting at the Sheraton-Brock Hotel, Niagara Falls, Ontario, Canada on February 26, 1954.

Mr. Frank L. LaQue was the speaker for the technical portion of the meeting. Mr. LaQue spoke on the subject of "Some Anomalies of Corrosion Testing."

30 to 40 Percent of U. S. Steel Output Lost to Corrosion

Louis V. McIntire, of Southwestern Louisiana Institute, Lafayette, Louisiana, spoke on "The Eight Forms of Corrosion and Methods of Retarding Its Progress" before 40 members and guests attending the February 18 meeting of the Teche Section. Dr. McIntire said that between 30 and 40 percent of the United States' annual output of steel goes to replace loss by corrosion. He added that the petroleum industry's share of this expense added to other direct costs such as labor for repair and prevention, is in excess of \$600 million annually.

In discussing the eight general classifications of corrosion, namely; galvanic, or bi-metallic corrosion, concentration cell corrosion or solution cell, pitting, dezincification, stress corrosion, intergranular corrosion, erosion corrosion and uniform attack or general corrosion, Dr. McIntire said these should not be construed as the only types of corrosion and that some of these types can overlap. He said a basic principle found in dealing with corrosion that must be understood first is that the basic element of iron is always trying to give up or transfer electrons. In listing a few preventive measures, he named cathodic protection and the use of similar materials to combat galvanic corrosion. To avoid pitting corrosion avoid concentrations of halogen ions and applications of cathodic protection; to prevent dezincification use a metal with 85 percent copper and avoid high temperatures; to combat stress corrosion use cathodic protection; to mitigate intergranular corrosion, water quenching is suggested; for combating erosion-corrosion proper design and the avoidance of high velocities are recommended. After Dr. McIntire's talk, local problems in corrosion were discussed by round-table method.

The nominating committee for the Teche Section announced nominees for officers for 1954 as J. H. Booksh, Jr., and R. S. Morcom for chairman; Vernon Sibille for vice-chairman; D. D. Billodeau and Ralph J. Rice for secretary-treasurer; G. M. Harper, Jr., and Gus Vogler for Trustee.

Southeast Region's New Director is E. P. Tait

Southeast Region, NACE, has recently announced the results of a letter ballot for the election of a director to represent the Southeast Regional Division on the board of directors of the National Association of Corrosion Engineers. E. P. Tait, Alloy Steel Products Company, Atlanta, Georgia, was elected to take office on the last day of the 1954 NACE Conference and Exhibition. Mr. Tait succeeds E. D. McCauley, American Cast Iron Pipe Company, Birmingham, Alabama, who has served on the NACE Board of Directors representing the Southeast Region since 1952.

100 Enroll in Washington State College Course



HALF OF THE SPEAKERS present for the Corrosion Short Course held at Washington State College, Pullman, February 1-5, are shown here. They are, left to right: Back row: V. V. Kendall, National Tube Division, United States Steel Corp., Pittsburgh; R. L. Albrook, Director Division of Industrial Research, Washington State College; M. J. Pryor, Metallurgy Div., Kaiser Aluminum & Chemical Corp., Spokane; H. H. Uhlig, Massachusetts Institute of Technology; C. Groot, Hanford Atomic Energy Plant, Richland, Wash.; I. Cornet, University of California, Berkeley. Front row: M. F. Adams, associate chemist, Division of Industrial Research, Washington State College; F. L. LaQue, The International Nickel Co., Inc.; H. A. Pray, Battelle Memorial Institute; A. L. Babb, Department Chairman Engineering, University of Washington; L. E. Hill, Pulp and Paper Div., Weyerhaeuser Lbr. Co., Everett, Wash.



SOME OF THOSE PRESENT at the banquet February 4 during the Corrosion Short Course held at Washington State College. Seated at the table facing the camera are, left to right: R. D. Sloan, Acting Director, Institute of Technology, Washington State College; Mrs. M. J. Pryor, V. V. Kendall, Mrs. M. F. Adams, F. L. LaQue; C. Clement French, president, Washington State College; H. H. Anderson, vice-president and general manager, Trans Mountain Oil Pipe Line Co., Vancouver; E. B. Moore, Chairman Department Civil Engineering, Washington State College; A. Wachter, NACE president; Mrs. C. Clement French; H. A. Pray, Mrs. E. B. Moore, M. J. Pryor and M. F. Adams, Division of Industrial Research, Washington State College.



NACE MEETINGS CALENDAR

April

- 12—St. Louis Section. Howard D. Segool, Plastic Tapes as Corrosion Control Coatings. York Hotel.
- 13—Houston Section.
- 15—Detroit Section.
- 16 or 20—Cleveland Section. Allerton Hotel. F. L. LaQue, The International Nickel Co., Inc., speaker.
- 20—Chicago Section. Dr. G. Gutzzeit, "The Kanigen Process."
- 27—Central Oklahoma Section. YWCA, Oklahoma City.
- 27—Southwestern Ohio. Plant tour, Hilton-Davis Chemical Company, dinner meeting and discussion of tour.

May

- 5—Greater Boston Section. Cathodic Protection, speaker to be named.
- 11—Houston Section.

- 18—Cleveland Section. R. B. Seymour, Atlas Mineral Products Co., Allerton Hotel.
- 20—Chicago Section. Round table discussion.
- 25—Central Oklahoma Section. YWCA, Oklahoma City.
- Southwestern Ohio Section. R. L. Featherly, The Dow Chemical Co., "Cathodic Protection."
- 27—Detroit Section.

"Niagara Frontier" Is New York Section Name

At a recent meeting of the Northeast Regional Board of Trustees, the Board approved the change in the name of the Western New York Section. The new name of the Section will be the "Niagara Frontier Section." The first meeting under this name will be held April 21, 1954 at the Hotel Statler in Buffalo, New York, and will consist of a five-man panel composed of Dr. M. G. Fontana, Dr. J. C. Searer, T. R. B. Watson, Dr. A. A. O'Kelly, and Dr. T. E. Gilbert.

The third in a series of corrosion short courses in the Western Region was held at Washington State College, Pullman, Washington, during the week of February 1-5. The course, following the pattern set by the NACE Education Committee, was sponsored by the Division of Industrial Services of the State College. General Chairman was Mark F. Adams, Associate Chemist, Division of Industrial Research, Washington State College. Local arrangements were handled by the staff of Industrial Services and E. B. Parker, director.

A total of 100 enrolled for the course including speakers, faculty and college students. The first day was devoted to fundamentals with H. H. Uhlig as lecturer. The motion picture, "Corrosion in Action" was shown in the evening. F. L. LaQue, director of the film, gave a short introduction concerning the production of the picture. H. H. Uhlig, consultant for the film, was also present to answer questions after the showing.

On Tuesday, F. L. LaQue, International Nickel Company, lectured on Corrosion Testing and Evaluation. In the afternoon, M. J. Pryor, Kaiser Aluminum and Chemical Corporation, lectured on Design of Equipment from the Corrosion Standpoint. A "mixer" was held in the evening.

H. A. Pray, Battelle Memorial Institute, discussed the general subject of coatings on Wednesday morning. In the afternoon, G. H. Rohrbach, Crest Research Laboratories, covered the subject of Cathodic Protection and Inhibitors. In the evening, V. V. Kendall, U. S. Steel, presented a bonus lecture on the use of Mathematical Statistics in Evaluating Corrosion Data.

On Thursday morning, V. V. Kendall, in cooperation with F. L. LaQue, presented and discussed the subject of Materials of Construction. In the afternoon, the assembly broke up into three groups for panel discussions, one on Corrosion Testing Techniques, one on Pulp, Paper and Wood Processing, and one on Public Utilities and Transportation.

The Short Course Banquet was held in the evening. Emmett Moore, chairman, Department of Civil Engineering, acted as master of ceremonies; H. H. Anderson, vice president and general manager, Trans-Mountain Pipe Line, spoke on "Selling Management on Corrosion Control." After the speech the film on the construction of the Trans-Mountain Pipe Line from Alberta to Vancouver was shown.

Friday morning, the subject of environment was covered by Aaron Wachter, NACE vice president, and president-elect. On Friday afternoon three more panel discussions were held, one on Food Processing and Agriculture, one on Chemical Industry and Sewage and one on Instrumentation.

This series of three short courses on corrosion fundamentals in the Western Region was sufficiently successful to warrant a repeat performance of the series. The first repeat in the series is scheduled for UCLA at Los Angeles in February 1955. Interspersed with the short courses on fundamentals there will be 2 and 3-day short courses on special subjects in each area each year.

Vancouver Section Hears Talk by Hilary Humble

Hilary Humble, manager of Cathodic Protection Department, The Dow Chemical Company, Midland, Mich., spoke to 37 members and guests of Vancouver Section February 5.

After outlining the general theory of corrosion and cathodic protection Mr. Humble illustrated his talk on how cathodic protection may be applied successfully. Applications covered a wide variety of conditions.

F. Mitchell asked about protection under barnacles, and Mr. Humble said complete protection can be expected.

I. D. G. Berwick, inquiring about recent experiments by Mr. Humble and T. P. May of The International Nickel Co., Inc., asked if stainless steels could be protected cathodically. Mr. Humble said polarization grows slowly but essentially prevents corrosion.

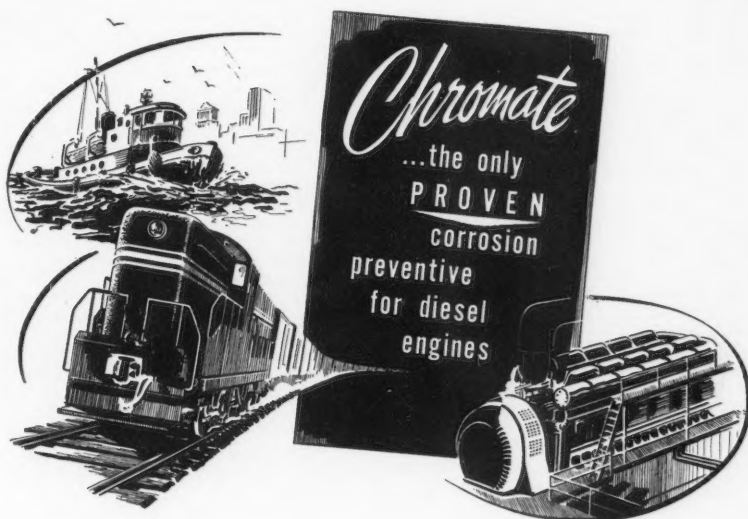
C. Cates asked about cathodic protection of one-through marine engine cooling systems, saying magnesium blocks gave some measure of protection. Mr. Humble replied that theoretically protection under these conditions was impossible. In closed systems the rise in pH accompanying dissolution of the magnesium and the possible protective action of magnesium salts on the water jacket might be helpful.

Monel, frequently used to sheath steel piling in the tidal zone, although cathodic to steel in any medium causes no more corrosion below tide level than would the aerated rusted steel it covers, Mr. Humble said. It further protects the steel in the tidal area.

Mr. Humble was given a Thunderbird tottem as a memento of British Columbia by F. Cazalet.



CANADIAN REGIONAL MEETING—Shown here are some of the 123 NACE members and guests attending the first annual Canadian Region meeting February 12 at the King Edward Hotel, Toronto. Standing at the microphone is T. R. B. Watson, chairman of the Toronto Section.



Aluminum Corrosion Is Topic at Pittsburgh

Eighty members and guests of the Pittsburgh Section toured the Aluminum Company of America Research Center in New Kensington, Pennsylvania at the March 4 meeting of the Section. Following the tour, slides showing "Resistance of Aluminum and Other Metals to Atmospheric Corrosion" were shown.

The next meeting scheduled for the Pittsburgh Section will be held at the Mellon Institute, Pittsburgh, Pennsylvania on April 1. At this meeting Dr. M. G. Fontana, Ohio State University, Columbus, will speak on "Corrosion and Its Prevention." Prior to the discussion by Dr. Fontana a motion picture, "Preliminary Investigation of Fretting Corrosion," will be shown.

W. L. Healy Elected

William L. Healy, General Electric Company, Philadelphia, has been re-elected president of the Standards Engineers Society. Madhu S. Gokdale, RCA Victor Division, Camden, N. J., was re-elected vice-president; Harold J. Nugent, Manufacturer's Representative, Philadelphia, treasurer and Fred M. Oberland, RCA Victor Division, Camden, secretary.

CHROMATES are the only tried and true answer to controlling cylinder-liner corrosion in diesel engines. Use of chromium inhibitors is universally accepted by locomotive builders.

Sodium chromate stops corrosion before it starts. The presence of this one chemical renders the metal surface passive to corrosive attack. Slight oxidizing action occurring upon initial contact produces an additional safeguard—a protective surface-deposit of iron and chromium oxides.

Deisel locomotives require only 2000 to 2500 ppm sodium chromate at pH 8.5 to 9.5 to minimize the combined effects of vibration and corrosion. Other

units such as standby boilers, stationary and marine diesels, hot water heating systems, and automobile radiators vary in their anti-corrosive requirements from 200 to 5000 ppm sodium chromate. It is important that sufficient chromate concentration be maintained at all times; to leave valuable equipment unprotected even for short periods may result in serious damage.

Mutual, the world's largest manufacturer of chromium chemicals, supplies the chromates necessary for cooling systems protection. Information about corrosion prevention in all types of cooling systems will be sent upon request.

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Panel on Metals Attracts 86 to Los Angeles

A 3-man panel on Use of Metals for Corrosion Resistance and Behavior of Metals in Corrosive Environments was the technical feature of the meeting of Los Angeles Section February 10. The dinner meeting was attended by 86 members and guests.

New officers of the section were installed at the March 24 meeting as follows: Sidney K. Gally, Pasadena, chairman; Edward H. Tandy, Standard Oil Co., of California, El Segundo, vice-chairman and John R. Brown, John R. Kobe, Inc., Inglewood, secretary-treasurer.

The panel consisted of A. Bayard Dod, sales engineer, Phelps Dodge Copper Products Corp.; A. P. Maradudin, Standard Oil Company of California, El Segundo and Barclay Morrison, manager specialty products, Alloy Tube Division, Carpenter Steel Co.

The following replies were given to a question concerning the service to be expected from austenitic chrome nickel stainless steels when intergranular corrosion is a serious problem in refinery service:

Mr. Morrison discussed intergranular corrosion with respect to the metallurgy, explaining that improper heat treatment causes carbide precipitation at grain boundaries. Corrective measures include additions of columbium, which produces Cb carbides at grain boundaries and leaves Cr free for corrosion protection. Titanium also is used for a similar reason but leaves the steel dirty. Reducing carbon as in the ELC grades is another answer, he said.

Mr. Maradudin pointed out intergranular corrosion is caused not only by lack of Cr but also by the galvanic effect between Cr carbide and low-Cr iron. Additives are not the full answer, he asserted, observing that even steels with these additions will corrode under extreme conditions. Proper heat treatment is a fundamental to give steel its best resistance to corrosion.

Stress Corrosion Differentiated

Mr. Maradudin also commented on the difference between intergranular corrosion and stress corrosion cracking. Stress corrosion cracking, the more prevalent of the two conditions, often is mistaken for intergranular corrosion. All austenitic alloys are subject to stress corrosion cracking, he said. Dual phase alloys (Types 316 and 317, for example) with molybdenum additions and having both austenite and ferrite present, are more corrosion resistant.

In reply to a question concerning the constituents of Alloy 20 Mr. Morrison said that all Alloy 20 sheet, pipe and wrought forms likely to be welded contain Cb for stability. Bar stocks, on the other hand, most likely to be machined, do not contain Cb as a rule.

Sea Water Exposures

Mr. Maradudin, in reply to an inquiry concerning the best metal for sea water exposure in the tidal zone, said Monel gives excellent service in hot or cold water.

Best metals for heat exchangers under three sets of conditions, according to Mr. Dod, are as follows:

Cold, very low velocity: Admiralty and Admiralty brass, at velocities up to

5 feet per second and at temperatures to 120 degrees F. Cold, high velocity: 70-30 cupro nickel gives good service in more severe environments, while at higher temperatures (100 to 130 degrees C), 95-5 aluminum bronze is very good. Because an intact corrosion product film is essential for the corrosion resistance of copper alloys, high velocities and turbulence cause severe corrosion, such as is found at inlet ends of tubes.

Other Salt Water Materials

While cast iron is extensively used in sea water, its low impact value reduces its usefulness. Cement lined pipe has a major drawback in that it is difficult to get good lining repairs at welded connections, and to adequately protect flanges. Monel, however, gives good service.

When dual corrodents are present, Mr. Morrison, explained, bi-metallic tubes are useful with the materials on both sides selected for best resistance to the corrosive medium contacting them. A commentor from the floor observed that aluminum has good corrosion resistance in oxidizing media.

Mr. Maradudin explained that aluminum is in a separate category and that it has wide use in refinery service.

In response to a question concerning the stability of aluminum alloys a commentor from the floor explained that aluminum alloys' best resistance was at environments near neutral pH; that is, they are attacked in environments of high or low pH.

Materials in Sulfuric Acid Fumes

When asked what metals were recommended for resistance to sulfuric acid fumes with 18 to 20 percent acid, Mr. Morrison said Alloy 20 gives good service, showing charts giving the relative resistance of Alloy 20, Hastelloy C at 176 degrees F and rates in boiling acid.

A question from the floor was: Can sulfuric acid be handled in rubber-lined equipment at all concentrations at temperatures under 200 degrees F? The reply was that the temperature must be held beneath the vulcanizing temperature of the rubber and that rubber can be used to coat heat transfer surfaces.

Mr. Morrison added that varying temperatures complicate the problem of dealing with fume duct corrosion. Droplets formed on metal surfaces are concentrated with temperatures increase and thus cause accelerated local corrosion.

Other Questions Answered

Other questions included: Is the indicated maximum corrosion rate of 40 mils per year of Alloy 20 satisfactory?

Mr. Morrison: These rates must be tolerated sometime because there is no more resistant material or it is not economical to use a more expensive alloy.

What Stainless steels can be used to handle nitric acid at concentrations over 40 percent, room temperature?

Mr. Morrison: For nitric acid alone, Types 430 and 304. When nitrate salts are present, Type 309 is good. Titanium is very good for combinations of hydrochloric acid and nitric-hydrochloric acid combinations.

Because of titanium's cost, it is used

in thin sheets attached to steel. Because of difficulty in fastening the titanium to steel it is reported some success has met attempts to bond Ti to steel with rubber.

Are inhibited Admiralty tubes preferred for heat exchangers?

Mr. Dod: Inhibited tubes are preferred for resistance to dezincification. All three inhibitors, As, Sb and P seem to work equally well.

What are allowable velocities for sea water in heat exchanger tubes at temperatures up to 120 degrees F?

Mr. Dod: Generally below 6 fps for Admiralty and about 7 to 8 fps for Al brass, Al bronze and cupro-nickel. Tolerable velocities depend on oxygen content of water.

Mr. Maradudin pointed out that besides oxygen, sand, sewage and other contaminants have influence. Type 329 alloy tubes have given good service under severe salt water conditions.

What material can be used for 85 percent phosphoric acid at 320 degrees F?

Mr. Maradudin said that when the acid is inhibited with copper sulfate, Type 316 ELC can be used.

Mr. Morrison added that recent tests indicated a corrosion rate in boiling phosphoric acid of 0.00013-inch per month for Hastelloy B, 0.040 ipm for Hastelloy C and 0.050 ipm for Alloy 20.

A commentor from the floor said crude phosphoric acid containing natural inhibitors can be handled at room temperature in mild steel containers and pure acid in rubber lined containers. Ceramic and glass-lined steel containers have been used successfully in severe acid service.

Mr. Maradudin commented that hydrogen sulfide often is blamed for severe corrosion actually resulting from oxygen, carbon dioxide and moisture, citing a steel pipe-line handling moist hydrogen sulfide successfully for a number of years. In other installations, he said, where hydrogen sulfide concentration is much lower, but some oxygen and carbon dioxide are present, the corrosion is severe.

Bulow Talks on Copper at Kanawha Valley

C. L. Bulow, Corrosion Metallurgist of the Bridgeport Brass Company, spoke on Copper and Copper Alloys, their corrosion resistance under various conditions; physical, mechanical and fabrication properties, at the March 11 meeting scheduled by the Kanawha Valley Section. He covered the influence of factors such as alloy composition, corrosive media, temperature, stress, corrosion inhibitors and cleanliness.

Mr. Bulow is active on ASTM Committee B-3 and NACE committee T-5A. He also is a member of ACS, Electrochemical Society, API and Institute of Metals.

In March, 1953 there were more NACE members in Texas alone than there were in the whole United States at the end of 1945, second year of the association's existence.

Joint Electrochemical Society - San Francisco Bay Section Meeting Held

At a dinner meeting held jointly by the San Francisco Bay Area Section and the San Francisco Local Chapter of The Electrochemical Society, H. H. Uhlig, Massachusetts Institute of Technology, Cambridge, Massachusetts, spoke on "Corrosion as an Electrochemical Process." One hundred members and guests from the two organizations heard Dr. Uhlig discuss briefly the early beginning of the fight against corrosion and then develop the fundamentals of corrosion as an electrochemical process. Throughout the talk Dr. Uhlig illustrated his theoretical points with striking practical incidents drawn from his own rich background in the field of corrosion.

20-Watt Transistor Has Been Developed

Armour Research Foundation's December, 1953 "Newsletter" reports Minneapolis-Honeywell Regulator Company has developed a thimble-size transistor with a 20-watt output.

The publication also reported heat from the Hanford plutonium plant at Richmond 5, Washington soon will be extracted by heat exchangers for use in the plant instead of discharged into the cooling water emptying into the river. The system is expected to amortize itself in 7½ years through fuel savings.

Corrosion Metallurgy to be Topic at Houston Section's April 13 Meeting

A panel on Metallurgy in Corrosive Environments will be the technical program for the April 13 Houston Section meeting. Moderator for the panel will be Charles Gribble, Jr., Metal Goods Corp. Members will be R. F. Clarkson, Mathieson Chemical Co.; Jack Rice, International Nickel Co., Inc.; Bill McClain of the University of Houston and Shell Oil Company Refinery and Mr. Weingarten, Humble Oil & Refining Co., Baytown.

At the March 9 meeting, approximately 85 Section members and guests heard Charles P. Dillon, Carbide & Carbon Chemicals Corp., speak on "Corrosion By Fresh Waters." In a well organized, comprehensive talk, Mr. Dillon first listed individual metals and what he had found to be their reaction to fresh water. Corrosion by fresh water is more of a problem than most engineers realize, Mr. Dillon said. The chemistry of fresh water corrosion is rather complex and an empirical approach is customarily used to find a solution, he continued.

The corrosion of metals in water is primarily under cathodic control, Mr. Dillon said. In the presence of a replenishable supply of oxygen, the amount of corrosion current flowing is directly proportional to the area of the cathode. Since oxygen usually is necessary for corrosion to proceed, the rate of diffu-

sion of oxygen to the metal surface is the second most important factor.

Mr. Dillon pointed out a peculiarity of zinc under varying temperatures and in waters of a special type. Zinc, normally anodic to steel will reverse its potential in certain waters when the temperature is approximately 60° C or above. The zinc then becomes cathodic to steel which results in increased attack on the ferrous metal.

Various means of combating corrosion in once-through cooling water and recirculated cooling water systems were outlined by Mr. Dillon. Covering the metals with paints and coatings, substitution of non-metallic materials and the use of inhibitors were listed as preventive methods. Inhibitory treatment of water is not practical in once-through cooling systems, he said. It is not very

difficult to inhibit corrosion of metals in recirculated cooling waters, but to do so with optimum results and minimum expense requires a careful scientific appraisal, he cautioned. Supplementing coatings with cathodic protection was also mentioned.

In assessing corrosion by joining dissimilar metals, Mr. Dillon pointed out that by experimentation it was found that the amount of current flowing between copper alloys and austenitic grades of stainless steel was negligible, even with a cathode 20 to 40 times the area of the anode. In the case cited, Mr. Dillon said that even though the corrosion rate of the copper was doubled, the rise of .006 inches per year to .0012 inches per year was considered of no practical importance.

FEDERATED METALS OFFERS NEW REPORT: "CATHODIC PROTECTION WITH ZINC ANODES"

Federated's Corrosion Advisory Service offers you, without obligation, a new report titled, "Cathodic Protection With Zinc Anodes," prepared by Ebasco Services Inc. for the American Zinc Institute. This new publication reports additional findings obtained since the first report was issued in November, 1951. In it you will find important and valuable facts that have influence on the proper applications of zinc anodes. Use coupon below for your free copy.

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Petrochemical Corrosion Discussed at Philadelphia

The first 1954 technical meeting of Philadelphia Section was held February 12, with 78 members and guests attending the dinner and technical session. B. B. Morton, of International Nickel Company, Inc., New York, New York, spoke on "Corrosion Resistant Materials in Petrochemical Fields." Mr. Morton illustrated his talk with many photographs and charts and described the oil industry's adaptation of chrome, Monel, cast iron, steel and aluminum alloys to uses in corrosive environments. He also discussed corrosion of steel structure in off-shore drilling rigs, problems with heat exchange units and protection against the sulfur content in crude oils.

F. K. Shankweiler, Hercules Powder Company, Wilmington, Delaware, spoke on "Chlorinated Rubber Base Paints." Mr. Shankweiler listed seven types of paints arranged with weighted ratings reflecting their relative economics and performances. The varied uses of chlorinated rubber and selection of primers to be used with chlorinated rubber coatings were examined in considerable detail through the use of slides.

The following committee chairmen for 1954 were introduced at the meeting: Program Committee, J. James Hur, Atlantic Refining Company; Arrangements Committee, Earl D. Bossert, Bell Telephone Company; Membership Committee, S. B. McWhorter, Lithcote Corporation; Fellowship Committee, A. A. Boova, Atlas Mineral Products Company; By-Laws Committee, W. R. Briggs, W. A. Briggs Bitumen Company; Publicity Committee, J. J. Meany, A. V. Smith Engineering Company.

160 Register for Short Course in Corrosion Control Sponsored by Shreveport Section

Berkeley Conference on Marine Corrosion Is Attended by 76 Persons

The Conference on Marine Corrosion Problems held at Berkeley, Calif., Feb. 8-9, was attended by 76 persons. The conference was sponsored by the National Association of Corrosion Engineers cooperating with the department of engineering, university extension of the University of California.

While most of those attending were from California, there were representatives from four other states. States represented were: New York, Texas, Oklahoma, and Washington. One resident of Australia, temporarily residing in California, also attended.

Petroleum companies were represented by 21 registrants; suppliers, fabricators and contractors by 16; naval installations by 14; marine industries by 8; university students, 4; state and municipal governments, 4; public utility, 4; and consultants, engineers and others, 5. Suggestions from those attending that the conference be held in 1955 or 1956 attested the success of this year's meeting.

Petroleum Microbiology Discussed at Ft. Worth

David M. Updegraff, Magnolia Petroleum Company, Field Research Laboratories, spoke on Petroleum Microbiology at the March meeting of the North Texas Section held in Fort Worth. Dr. Updegraff said that the field of petroleum microbiology includes the relationship of microorganisms to the origin of petroleum deposits, petroleum production, exploration for petroleum and the refining and manufacture of petroleum products.

He explained that applied research in petroleum microbiology has its roots in fundamental discoveries made largely by German and Russian microbiologists, between 1900 and 1940; that since 1945 the major American oil companies have become aware of the potential practical value of this field and that most of them are now actively pursuing research in one or more branches of petroleum microbiology. He said, "Research carried out by API-financed projects, directed by Zo Bell and by Stone, have shown that bacteria are of major importance in modifying the chemical structure of the organic source material of petroleum during the early stages of its deposition in sediments. Bacteria were also shown to produce saturated hydrocarbons as well as to consume them."

"Microorganisms are of importance in petroleum production in several ways. They cause anaerobic corrosion of iron and steel, fermentation of organic additives in drilling mud, plugging of formations during water flooding and may be useful in the secondary recovery of oil. Bacteria capable of oxidizing

(Continued on Page 9)

Shreveport Section's Short Course in Corrosion Control was held on the Centenary College campus, Shreveport, Louisiana, February 18-19. One hundred and sixty registered for the course. Attendance consisted of operating personnel, engineers, sales and service company representatives from Texas, Louisiana, Arkansas, Mississippi and Alabama.

Local arrangements for the Course were directed by M. J. Olive, Arkansas-Louisiana Fuel Oil Company, Tom Holcombe and Ned Stearns, the latter both of Holcombe and Stearns Company and officers of the local section. Centenary College officers and staff, especially Dr. John B. Entriken, Head of Chemistry Department, also assisted. Papers given at the short course and their authors were:

Management's View on Corrosion Control, J. L. Seger, President, Interstate Oil Pipe Line Company, Shreveport, La.

Fundamental Causes and Control of Corrosion, H. V. Beezley, United Gas Corporation, Shreveport, La.

Economics of Corrosion Control, R. L. Bullock, Interstate Oil Pipe Line Company, Shreveport, La.

Insulating Materials and Practices, R. B. Bender, Plastic Engineering & Sales Corp., Fort Worth, Texas.

Underground Protective Coatings, E. A. Koenig, Vice-President, Wilcox Trend Gathering System, Inc., Dallas, Texas.

Fundamentals of Cathodic Protection, Gordon Doremus, Cathodic Protection Service, Houston, Texas.

Corrosion Control in Congested Areas, C. L. Woody, United Gas Corporation, Houston, Texas.

Above Ground Protective Coatings, Howell C. Owens, Coast Paint & Lacquer Co., Inc., Houston, Texas.

Plastics for Corrosion Control, George Holm, Tube Kote, Inc., Houston, Texas.

Causes and Mechanics of Internal Corrosion, George Purdy, Tretolite Company, St. Louis, Mo.

Application of Corrosion Inhibitors in the Oil and Gas Industry, Parke Muir, Dowell, Inc., Tulsa, Okla.

Plant and Tank Corrosion, S. S. McGill, International Paper Company, Springhill, La.

Inspection and Field Testing Practices for Internal Corrosion, E. H. Sullivan, United Gas Corporation, Shreveport, La.

Participating in a round table discussion on corrosion and corrosion control were: W. A. Broome, Arkansas Louisiana Gas Company; R. L. Bullock, Interstate Oil Pipe Line Company; E. H. Sullivan, United Gas Corporation; C. L. Woody, United Gas Corporation.

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39 Papers to Be Given At Buffalo Meeting Of Welding Society

Among the 39 technical papers to be presented at the Buffalo, N. Y., May 4-7 meeting of the American Welding Society are the following of corrosion interest:

Wednesday, May 5

Comparison of the Various Methods for the Determination of the Percent of Ferrite Content in Type 347 Stainless Steel Weld Deposits by W. J. Fleischmann, General Electric Co.

Production of Welded Stainless Steel Pipe by A. Grodner, Alloy Fabricators Div.

Thursday, May 6

Surface Embrittlement of Titanium by Exposure of Weld Heat-Affected Zone to Atmospheric Contamination by C. E. Hartbower, D. M. Daley, Jr., and W. P. Hatch, Jr., Watertown Arsenal.

Effect of Alloying Elements on Welds in Titanium. Part II. By G. E. Faulkner, Battelle Memorial Institute.

High Temperature Alloy Fusion Brazing for Titanium and Titanium Alloys by Roger A. Long and Robert Ruppender, Aircraft Components Div., Ferrotherm Co.

Friday, May 7

Brazing Molybdenum for High Temperature Service by M. I. Jacobson, D. C. Martin and C. B. Voldrich, Battelle Memorial Institute.

Welding 90/10 Copper-Nickel Alloy by G. R. Pease and T. E. Kihlgren, International Nickel Co.

Welding Procedure for Welding Tubes in Heat Exchangers by W. E. Battles and W. E. Spires, Leader Iron Works, Inc.

Oklahoma City Group Hears Ted Canfield

Twenty-five members and guests heard Ted Canfield, Consolidated Natural Gas Company, Oklahoma City, Oklahoma, speak on underground corrosion problems in pipe line systems at the February 23 meeting held by the Central Oklahoma Section. Mr. Canfield's talk aroused considerable discussion among those present, especially the topic of surface potential method of determining corrosive areas brought out in his talk.

Roadhouse Talks at St. Louis February 8

John B. Roadhouse, Owens-Corning Fiberglas Corporation, Toledo, Ohio, spoke on "Fiberglas—Its Application in Corrosion Control of Underground Pipe Lines" before 25 members and guests who attended the February 8 meeting of the Greater St. Louis Section in St. Louis, Mo. Mr. Roadhouse presented a short color motion picture illustrating the construction of a pipe line with the operations of preparing the right-of-way, ditching, welding, coating, wrapping,

lowering in and back-filling. Following the motion picture, Mr. Roadhouse discussed the ways in which pipe coatings help to combat the forces of corrosion.

The speaker is a graduate of the University of Illinois, with a BS in Industrial Administration. He has been employed by the Owens-Corning Fiberglas Corporation for the past 15 years and is at present manager of pipe wrap sales.

several U. S. patents on the subject. The petroleum industry has done little to exploit the use of microorganisms in refining and manufacturing. However, there are U. S. patents on methods of producing valuable organic chemicals by the action of bacteria on natural gas and bacterial desulfurization of crude oil."

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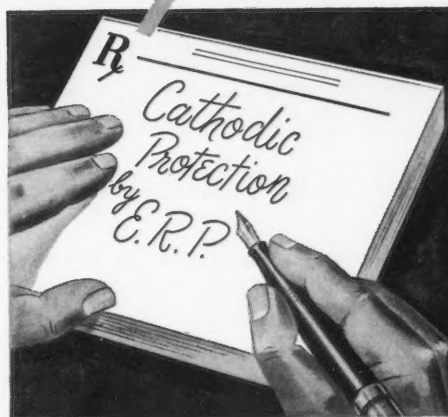
High-visibility purple has been adopted as an identifying color for equipment contaminated by or likely to emit damaging radiation. The American Standards Association has included this designation in its American Standard Safety Color Code.

Petroleum Microbiology—

(Continued from Page 8)

hydrocarbon gases have been employed as an index of sub-surface oil and gas deposits. The Russians have allegedly had some success in this and there are

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Houston Section Active During Engineers' Week

Houston Section of NACE took an active part in the celebrating of Engineer's Week, February 21-27. With the cooperation of several members the section erected a window display in a bank in Houston's downtown area.

Theme of the display was: Corrosion, Its Cost and Prevention. By unusual coincidence, a water main buried in the busy street spring a leak directly in front of the window, swelling the pavement and flooding the intersection. It was a striking example of the results of corrosion.

The window space was secured for the section's use by Joe Caldwell,

Humble Oil and Refining Co., Section vice-chairman. One unit of the display was made up of a corrosion demonstration unit consisting of five glass beakers which contained salt water. A piece of black iron pipe was inserted in one beaker. A galvanized iron pipe in the second. A piece of copper bonded to a piece of black iron pipe in the third showed how copper speeded corrosion of the iron. Sacrificial anode protection was illustrated by the fourth beaker which contained a zinc anode bonded to black iron. Cathodic protection with impressed current was shown in the fifth beaker; a dry cell was used along with a piece of copper and black iron pipe. The current reversed the usual corrosion process, causing the copper to corrode to protect the black iron. Lyle Sheppard,

Shell Pipe Line Co., originated the display.

Norman Hamner, NACE Central Office, contributed a corroded water tank which was perforated after only three years of service. Alvan Rickey, Cathodic Protection Service, supplied a sacrificial anode used to protect hot water heaters. F. W. Gartner, Jr., F. W. Gartner Co., furnished samples of metal coated panels.

Charles Gribble, Jr. of Metal Goods Corp., supplied various metal panels. W. H. Edwards, the Superior Oil Co., supplied a piece of corrosion-perforated pipe. Cordele Garner, the Tube-Kote Co., furnished a cutaway section of coated pipe to show protection against perforation by corrosion. To show corrosion protection by paints, Sidney Smith, Napko Paint and Varnish Works, contributed some painted panels. Over all planning and theme of the window was done by Section Chairman L. G. Sharpe, Humble Pipe Line Co., who was assisted by John Simons, Central Office, NACE.

John P. Roberts

John P. Roberts, a member of the National Association of Corrosion Engineers since 1947, died January 27 in an Oklahoma City hospital after a brief illness. Mr. Roberts was quite active in association affairs, having led in the organization of the NACE Houston Junior Section when he was on the university faculty.

In 1951 Mr. Roberts left the University of Houston to become associate professor of mechanics and engineering metallurgy at the University of Oklahoma. He took an active part in Central Oklahoma Section work. He was in charge of the recent Corrosion Seminar at the University of Oklahoma.

Mr. Roberts was born March 7, 1908, in Brooklyn, N. Y., and attended St. John's preparatory school there. He received a bachelor of science degree in chemical engineering at the University of Pennsylvania in 1930 and a master of science degree in metallurgy at Massachusetts Institute of Technology in 1940.

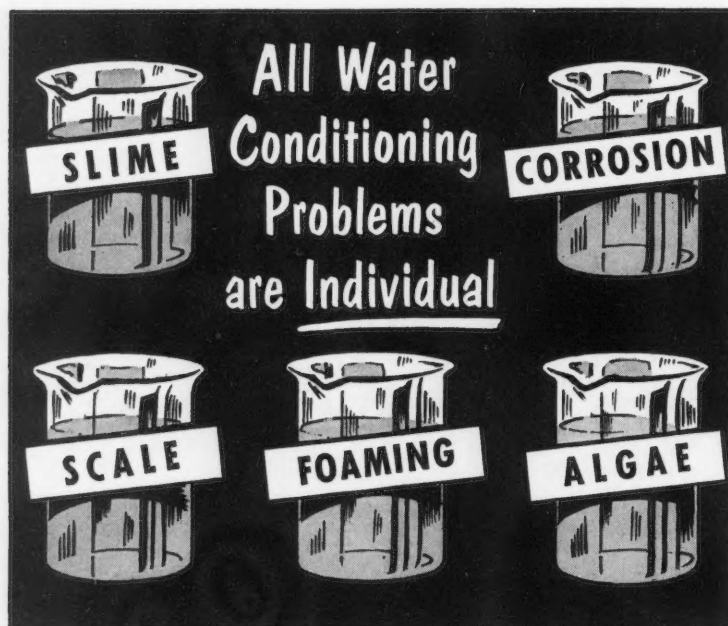
He was chief metallurgist for Industrial Welding and Testing Laboratories, Hamilton, Texas; staff metallurgist at Associate Testing Services, Fort Worth, and engineer of tests with the M. L. Ross Co., Brooklyn, N. Y.

In addition to membership in NACE, Mr. Roberts was a member of American Society for Metals, Electrochemical Society, American Electro-Platers Society, Society of Engineers and American Society of Engineering Education. He was also a member of the Lions club; Sigma Tau, honorary engineering society and Alpha Phi Omega, national service fraternity.

He is survived by his widow; his mother, Mrs. M. R. Ross, Norman, Oklahoma; a daughter, Mrs. J. E. Fondon, Houston, Texas; three sons, Tracy L. Roberts, assigned to the Air Force in Manila, Philippine Islands; John A. Roberts, Seattle, Wash. and Richard L. Roberts, Houston, Texas, and three grandchildren.

Galvanizer's Committee

The 31st meeting of the Galvanizers Committee, sponsored by the American Zinc Institute will be held April 20-21 at St. Louis, Mo.



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Numerous Decisions on Corrosion Matters Made By ASTM Committees

Among decisions at meetings of technical committees of the American Society for Testing Materials at Washington, D.C., February 1-5 inclusive are the following of importance to corrosion workers:

Committee A-5 on Corrosion of Iron and Steel. Tentative standards are being submitted by letter ballot to the committee on a hot dip zinc coating on fabricated steel products, recommended practices for safeguarding against warpage while hot dipping and for safeguarding against inferior coatings. The committee voted, subject to letter ballot to concurrent action of Committee B-8 to adopt Specification A 219, Methods of Test for Local Thickness of Electrodeposited Coatings. Subcommittee XVI on Hardware Tests crystallized a program for a new series of atmospheric tests on hardware. Exposures at New York City, Kure Beach of flats, unthreaded rods, and flats with a cold bend of carbon and three alloy steels coated with hot-dip zinc, hot-dip aluminum and electroplated zinc are planned.

Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys. The recommended practice for passivation and cleaning stainless steel equipment is out to letter ballot. A draft of recommended practice for the acid copper-sulfate test is under consideration as is the oxalic acid etch test as an alternate to the boiling nitric acid test. With the help of AISI an extensive program of atmospheric exposure of stainless steel specimens is nearing completion. Eight grades of stainless steels are being tested at Pittsburgh.

The chromium and nickel ranges for the HF alloy have been narrowed. Specification A 167 on Corrosion Resisting Chromium-Nickel Steel Plate, Sheet and Strip and A 177 for high strength grades of the same material are being studied with the view of including AISI tolerances and type numbers.

Subcommittee XII on Specifications for High-Temperature, Super-Strength Alloys has completed a compilation of chemical compositions and rupture properties. Continued as an emergency alternate specification was a columbium-tantalum combination in addition to straight columbium in the columbium modified steels.

Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys. Modification of B 117 Salt Spray Test to specify 5 percent instead of 20 percent solutions is under consideration. A new tentative will be proposed embodying the acetic acid modification of the test. Specimens removed from atmospheric test racks after 20-year exposure have been cleaned and are being weighed. Spool-type specimens of the magnesium galvanic couple program have been exposed and evaluated and a report is being prepared. A symposium on Atmospheric Exposure Tests on Non-Ferrous Metals is being planned for June, 1955.

Committee B-7 on Light Metals and Alloys, Cast and Wrought. Results of one-year exposure tests at New York State College and Kure Beach and the 6-months' test at Point Reyes are being evaluated. Specimens will be exposed

at facilities provided at Freeport, Texas, in the next few months.

Committee B-8 on Electrodeposited Metallic Coatings. Tin and tin-alloy coatings, including tin-lead and tin-cadmium are to be studied as to corrosion resistance, among other things. Later studies are to be made of tin-copper, tin-nickel and tin-cadmium coatings.

BOOK REVIEWS

Good Painting Practice. Volume 1. Steel Structures Painting Manual. Joseph Bigos, Editor. 423 pages plus viii, 8½ x 11 inches. Cloth. 1954. Steel Structures Painting Council, 4400 Fifth Ave., Pittsburgh 13, Pa. Per Copy, \$6.00.

This is a compilation of recommendations on painting collected under the auspices of the Steel Structures Painting Council's 19 member organizations. Each of the eighteen chapters is authored by a person selected for his knowledge of the subject. Chapters are liberally illustrated and referenced.

Subject headings are: Simplified Theory of Corrosion, Mechanical Surface Preparation, Chemical Surface Preparation, Practical Aspects, Use and Application of Paints; Inspection, Quality Control of Paints, Comparative Costs, Shop Painting of Steel in Fabricating Plants, Painting of Railroad Bridges and Structures, Painting of Steel Vessels for Salt Water Service, Painting of Steel Vessels for Fresh Water Service, Painting of Steel Tanks, Painting of Steel in Hydraulic Structures, Protection of Pipelines and Other Underground Structures, Water and Sewage Works Structures, Maintenance Painting of Steel and Coke Oven Plants, Petroleum Refineries, Chemical Plants, Color in Industrial Plants, Metallizing and Causes and Prevention of Paint Failure.

Symposium on Tin. 6 x 9 inches, 111 pages, paper cover. 1953. American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. Per copy\$2.50

This booklet consists of seven items, six papers presented at the 55th Annual Meeting of ASTM at New York in June, 1952 and one item a panel discussion "The Analysis of Tin." As is pointed out by Frederick A. Lowenheim in one of the papers The Production and Uses of Tin Coatings, "corrosion resistance or protection is seldom the primary reason for the choice of tin as a coating . . ." The various characteristics of tin, its numerous uses, methods by which it is applied, reasons for its use, effect of impurities (82 references) determination of impurities and other facts are enumerated.

Report on The Elevated-Temperature Properties of Chromium-Molybdenum Steels. 8½ x 11, 208 pages, 1953. The American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. Per copy.....\$4.75

This report consists of data compiled by and issued under the auspices of the Data and Publications Panel of the ASTM and American Society of Mechanical Engineers Joint Committee on

(Continued on Page 14)

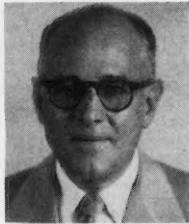
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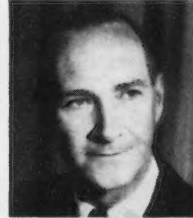
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H. M. HUGHES
Senior Engineer



C. A. GEDDES, JR.
Senior Engineer

in NEW ORLEANS



J. T. CONDRY
Senior Engineer



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Senior Engineer

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Western Region Address by H. H. Anderson on "Selling Management on Corrosion Control" *

By H. H. ANDERSON*

MY SUBJECT is "Selling Management on Corrosion Control." The engineers in this region of NACE have made a special effort to bring to this meeting a number of guests from management, some of their employers and some of their neighbors. Perhaps some of them hope I can help them sell their own employers more fully on the work they are doing. Others, I am sure, want me to help them sell their neighbors on more interest in corrosion control and in NACE.

The annual cost of corrosion is a serious loss to our national economy, and a direct loss to each company that operates substantial tonnages of metallic plant. In fact, because the customer ultimately pays the costs of all goods and services, it is a direct loss to all of us as consumers.

It has been estimated that most of this huge loss can be stopped by intelligent control of corrosion. Can we deny that such a program will benefit everyone? As consumers we will benefit by not having eventually to pay the bill. Operating companies will benefit by not having to include such costs in charges for products, utilities and services.

Suppliers of corrosion preventives will benefit by the fair profit they can make from a legitimate business. Corrosion engineers will benefit by continued gainful and respected employment. And NACE will benefit by continuing as the recognized forum to spearhead a great utilitarian program.

I had the privilege of discussing conservation of manpower and materials before the American Society of Mechanical Engineers recently. Concerning conservation to be achieved through corrosion control, the following ideas were expressed:

"All metallic plant is subject to corrosion. Apathy to its control can be laid to managers who are slow to see the direct losses from corrosion and to connect the indirect losses with their cause. But the fault is not all theirs. Some of their engineers and operating supervisors have failed to sell them on control measures. These, of course, cost money that requires budget approval. Thus education of management in the economic value of corrosion control is prerequisite to the great conservation it can achieve.

"Engineers should design structures and equipment so as to minimize cor-

rosion possibilities. Such includes selection and placement of materials resistant to corrosion and, where possible, avoiding the contact of dissimilar metals. Underground corrosion can be minimized by insulating structures from soil and water and by locating them so as to minimize their susceptibility to railway and cathodic stray current damage.

"Construction and operating supervisors, too, can conserve metal by avoiding corrosion. For example, during construction as well as operation, needless underground corrosion can be prevented by avoiding the disposal of waste matter or effluent where it may pollute the soil in or near the plant. Effective surface drainage will reduce this likelihood. Disposal of corrosive effluent gases is not always controllable, but careful selection of disposal locations with reference to structure location and prevailing winds can minimize their damage."

Benefits Are Obvious

As a member of NACE, which is strictly a non-profit technical association, I ask who can challenge the importance and widespread benefit of our effort to promote corrosion control? Is it any wonder that during the past five years the numbers of NACE members have grown phenomenally from 800 to 4300 individual members and from 50 to 370 company members?

The individual members of NACE, most of whom are corrosion specialists, through their exceptional zeal and enthusiasm, have done a splendid job in selling our program to hundreds—yes, thousands—of fellow specialists. But somehow many of them lack the knack of selling their managements and their neighbors' managements. The old proverb, "a prophet is not without honor save in his own time and country," might seem to apply.

As an ex-engineer who made the grade to the management level 23 years ago, I have presumed to sit in my ivory tower and conjecture why this condition should prevail. The condition is indeed unfortunate and I feel that perhaps both the managers and the engineers should share the fault. The basic principles underlying most corrosion and its prevention are rather simple, but specific corrosion mechanisms and specific preventive techniques differ widely and may be very complex. Moreover, there is still a dearth of concise data on the economic savings of corrosion control, particularly in the hands of companies that have been unfamiliar with or resistant to its use.

Perhaps we managers are prone to blame our engineers and operating men if they have failed to point out the extent and real cost of our company's corrosion losses. But I doubt if our directors would let us pass the buck and escape our more senior responsibilities for economic administration. We would be better advised to call in our subordinates and demand that the whole plant be competently surveyed so that we can tell the directors and finance the needed and usually profitable corrective measures.

To Help Is Proper

Be that as it may, from 1947 to 1952, as Chairman of NACE's Membership

Committee, I devoted much time and a lot of my then company's money toward selling industrial management on the value of corrosion control and support of the NACE program. It is proper that each of us should help our fellow citizens. For example, some of you work to help the fight against tuberculosis. I have chosen to help the fight against tuberculosis of metal. Can we deny its importance, with its 5½ billion dollar annual cost and the recent shortages of metals for defense?

And as regards spending company money in the effort, my management is sold on the philosophy of NACE, which is that the more experience we can pool in this fight against the enemy, the greater is the opportunity for each of us to benefit. We learn from each other and none of us can afford to be self-sufficient. And we can often learn as much from others' mistakes as we can from their successes. The pipeline company which I then managed has nearly \$100,000,000 worth of metal plant in service and we operated about \$25,000,000 worth for others. Thus the new ideas it gleans through NACE contacts to reduce its heavy annual maintenance cost are very profitable.

Corrosion Is Universal

All of us seek through our trade associations to swap experience on problems peculiar to our own industries. But corrosion is no respecter of industries. A piece of metal in given circumstances will corrode regardless of whether it is in an oil well or a steamship, in a zinc mine or a soap factory. NACE provides the driller, the mariner, the miner and the soap-maker a forum in which they can swap experience with opportunities for benefit that far transcends their separate trade associations.

We who already belong to NACE are not completely altruistic in trying to extend its benefits to others. We know that they will benefit by the fund of experience we can offer them. Yet we also know that we can expect to gain experience from newcomers.

Yes, indeed, we in NACE have something of real merit to sell. But we, too, face the problem of every salesman—that of learning enough about the customer to sell him on the need for our commodity. Our normal good sense tells us that every operator of metallic plant has corrosion problems of some kind that can be solved with our help. Yet—if we do not know the nature of the problems—we are handicapped in making our helpfulness evident to him. And if perchance he has not recognized his own problems, our handicap is even greater.

Let me recite two or three examples experienced personally while Chairman of the Membership Committee. I had corresponded for some time with the operating vice-president of one of our largest railroads and had been assured that his corrosion problems were nil. Then in November 1950 I found an article by the mechanical superintendent of an equally large and perhaps even more progressive competitor, reciting chapter and verse to prove that his company was losing millions annually due to corrosion of rolling stock alone. He estimated that the combined bill of the American railroads—based on his own company's experience—for rolling stock corrosion is about \$350,000,000 per year. NACE soon had at least twelve corporate members in the railroad in-

(Continued on Page 15)

* A talk given at the meeting of the National Association of Corrosion Engineers' Western Region meeting at Los Angeles, Cal., November 19-20, 1953.
* Vice-president, Trans Mountain Oil Pipe Line Company.

BOOK REVIEWS

(Continued from Page 12)

the Effect of Temperatures on the Properties of Metals. It consists principally of 200 figures and more than 250 data sheets on the subject. In all 53 analyses of steel are reported on. Data include creep and rupture strength and short time tensile properties.

H. H. Anderson—

(Continued from Page 14)

dustry, but many other roads would benefit also from membership. The Santa Fe, Southern Pacific and Union Pacific are NACE corporate members.

Another example: The operating executive of a fairly large southwestern electric power company consistently minimized the corrosion problems of his company. Given the opportunity in November 1951 to address the Petroleum Electric Power Association, I determined to find out more about it. By the simple expedient of merely reviewing the index of the NACE magazine CORROSION for the prior seven years and scanning a number of articles, I was able to list an array of corrosion problems besetting the electric power industry that was rather staggering. In generation—whether hydro-electric, steam or internal combustion stations—and in distribution—whether transformers, substation superstructures, transmission towers, overhead wire, pole-line hardware, and the sheaths of buried power cables—corrosion is evident in many costly forms. Then too, these public utilities can substantially boost their sale of electric energy for cathodic protection if they will team up with NACE to boost its program of corrosion control. These benefits have obviously been recognized by the 37 electric power companies that are NACE Corporate members, but what of the other 30 good-sized companies that have as yet not been sold on our helpfulness?

"Keep Up With Joneses"

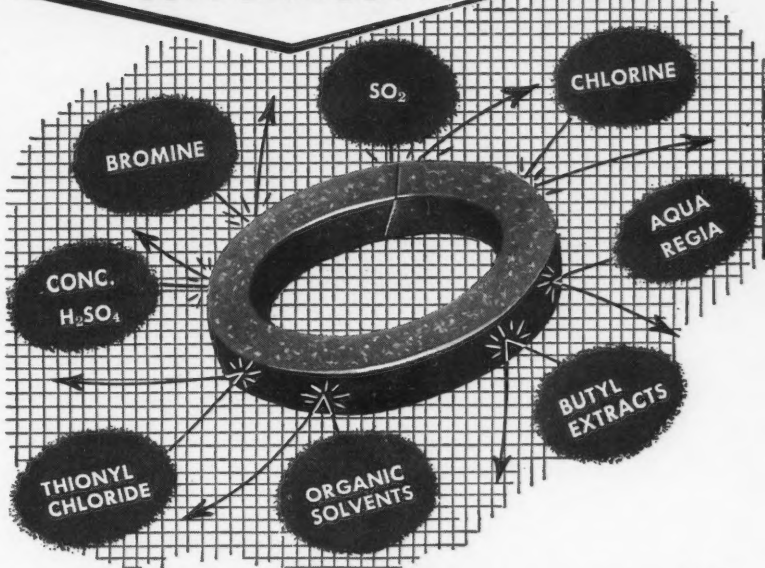
A type of sales approach that has proven effective is "keeping up with the Joneses." About two years ago four of the larger steel companies had not yet joined NACE despite many appeals and arguments. I prepared a list of the fourteen largest ones in their order of size and earmarked the other ten companies—some larger and some smaller—that had joined. I then wrote the chief executives of the four companies that perhaps "keeping up with the Joneses" was not a sound business maxim, but I couldn't understand why something deemed good by so many competitors was overlooked by them. This idea turned the trick and brought all of them in. (Including Jones & Laughlin, Inland, Wheeling and Wierston.) NACE now has about 30 corporate members in the iron and steel business, but other much smaller companies would profit by such affiliation.

A similar approach was tried recently on the producers and distributors of non-ferrous metals and with some success. But several large companies that stand to profit most from the sale of lead, zinc, magnesium, cast iron, bronzes and metallizing services (as corrosion preventives) have failed to recognize the made-to-order specialized market beckoning them through NACE membership. Some of our producers on the Pacific Coast could profitably join NACE.

Much of our nation's progress has been dependent on the oil and gas industry. Oil and gas can be made available only by the plentiful use of pipe. In fact, the oil and gas industry nationwide operates nearly 830,000 miles of buried steel pipe, not counting oil and gas well casings and tubing. Corrosion of this pipe is costing at least 2 or 3

(Continued on Page 16)

If you pump these corrosives...

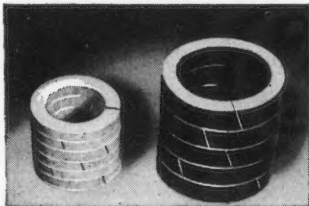


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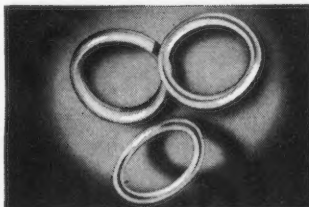
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Inter Society Corrosion Committee

CORROSION MEETINGS CALENDAR

April

13 American Society for Testing Materials, New York District, joint meeting with TAPPI, New York, New York.

20-23 Indiana Gas Association, Annual Meeting, French Lick Springs Hotel, French Lick, Indiana.

20-23 American Gas Association, Distribution, Motor Vehicles and Corrosion Conference, Mount Royal Hotel, Montreal, Canada.

26-28 Southern Gas Association, Annual Convention, Houston, Texas.

May

2-6 The Engineering Chemical Society, Inc., LaSalle Hotel, Chicago, Illinois.

17-18 Society of Naval Architects and Marine Engineers, Spring Meeting, Olympic Hotel, Seattle, Washington.

24-26 American Gas Association, Production and Chemical Conference, William Penn Hotel, Pittsburgh, Pa.

27-28 Natural Gas and Petroleum Association of Canada, Prince Albert Hotel, Windsor, Ontario, Canada.

June

12-25 American Institute of Electrical Engineers, General Summer Meeting, Biltmore Hotel, Los Angeles, Calif.

13-18 American Society for Testing Materials, Annual Meeting and Exhibit, Sherman Hotel, Chicago, Ill.

20-24 Canadian Gas Association, Banff Springs Hotel, Banff, Alberta, Canada.

28-29 Michigan Gas Association, The Grand Hotel, Mackinac Island, Michigan.

(No Date) National District Heating Association, Annual Meeting.

July

11-14 American Society of Refrigerating Engineers, Hotel Olympic, Seattle, Washington.

Sept.

8-10 Pacific Coast Gas Association, Victoria, British Columbia.

28-29 Texas Mid-Continent Oil and Gas Association, Baker Hotel, Dallas, Texas.

Sept. 29-Oct. 1 Porcelain Enamel Institute, Annual Meeting, The Greenbriar, White Sulphur Springs, West Virginia.

Oct.

3-7 The Electrochemical Society, Fall Meeting, Boston, Mass.

11-14 American Gas Association, Annual Convention, Atlantic City, New Jersey.

11-15 American Institute of Electrical Engineers, General Fall Meeting, Hotel Morrison, Chicago, Ill.

12-15 National Association of Corrosion Engineers, South Central Regional Meeting, Dallas, Texas.

Nov.

1-3 American Institute of Mining and Metallurgical Engineers, Institute of Metals Division, Fall Meeting, Sheraton Hotel, Chicago, Ill.

1-5 National Metal Exposition, Chicago, Ill.

8-11 American Petroleum Institute, Conrad Hilton Hotel, Chicago, Ill.

15-18 American Gas Association, Operating Section, Organization Meetings, Hotel New Yorker, New York.

1955

May

9-13 A.G.A. Industrial Gas School—(location to be announced).

16-18 Southern Gas Association, New Orleans, Louisiana.

June

5-9 Canadian Gas Association, Annual Meeting, General Brock Hotel, Niagara Falls, Ontario, Canada.

Oct.

17-19 A.G.A. Annual Convention, Los Angeles, California

17-21 National Metal Exposition, Detroit, Michigan (A.G.A. will exhibit). (Continued on Page 17)

H. H. Anderson—

(Continued from Page 15)

hundred million dollars every year. To pool their experience in curbing this type of loss is only one reason why about 140 oil and gas companies have NACE Corporate memberships. Here, again, many more companies can similarly benefit. Some major companies have two, three, four, five, or as many as seven

corporate memberships among their affiliates.

Repairs for Corrosion

And who gets this 2 or 3 hundred million dollars per year? Much of it goes to the steel companies, but a large share, too, is paid pipe line construction contractors for renewals, repairs and major reconditioning. On a renewal or reconditioning job, most of the contractor's work can be attributed to corrosion control. And even on modern new lines, a fair share of work involves the application of protective coatings to the pipe. Thus the promotion of corrosion control, as well as the need for it and of our NACE program is good business for pipe line construction contractors. Fifteen of them are now NACE Corporate members, but several others can equally benefit if they will join.

And what of the producers, purveyors and appliers of corrosion preventives, such as pipe line paints and enamels, glass and asbestos wraps, and the equipment or special engineering services needed to apply them? Some of them have corrosion problems in their own plants. But the very existence of most of them depends on the success of their sales effort. In this respect, the entree and camaraderie afforded by NACE membership are priceless. Many of these firms are NACE corporate members. Yet scores of others which profit so directly are contributing very little more financial support to NACE than perhaps to pick up the check for the inadequate amounts their sales engineers pay as active members. How about demanding more sales reciprocity!

Facts Prove Economy

Enough of examples. But I hope I have proved the obvious point that any engineer or manager—who has any inclination—can find cogent arguments why his company should foster the control of corrosion. If he seeks the facts, its economic profitability soon becomes evident.

And there is one last strong argument for control of corrosion: A Third World War is perhaps still hanging like the sword of Damocles over our heads and a heavy defense program still threatens our civilian supplies of metals. More than ever before, we should conserve the metals we have. Reduction of the ravages of corrosion will be a prime factor in this conservation.

Effective control of corrosion can be achieved only by engineers trained in its technology. These engineers can do their best only if they solve their general problems cooperatively. The best forum in which to do this is the NACE. Management should recognize this opportunity and encourage its engineers to participate actively in the association. And management should display sympathy for its engineers' problems on the job and should encourage and support the NACE program through corporate memberships.

Industry should never be apathetic to its own economic improvement. But today the conservation of metal is a national requirement instead of merely an economic desirability. At least for the duration of our "Cold War," the control of corrosion takes on new importance. If I have succeeded in making the economic opportunities and patriotic responsibilities evident to the managers and general engineers among you, I have accomplished my purpose.

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April, 1954

Illinois Technology Institute Publications

Among the publications reported by the Illinois Institute of Technology are the following:

Reactions of Metals with Gases at High Temperatures by P. Levesque.

Economics of Piping and Piping Maintenance for Industrial Plants by R. J. Pinske.

Stress Concentrations Due to a Hemispherical Pit at a Free Surface by Alonzo Robert Eubanks.

Effect of Molybdenum on Sigma Phase Formation in a Heat Resistant Steel by Ahmed El Bindarl.

Grain Refinement of Aluminum Alloys by Rodney Elliott.

The Kinetics of Age Hardening by David W. Levinson.

Structural Changes During Age Hardening by A. F. Weinberg.

Use of Polyester Resins in Product Design by Warren Diebold.

ASTE Will Meet in Philadelphia April 26-30

The 22nd Annual Meeting of the American Society of Tool Engineers will be held April 26-30 at Philadelphia. Among the technical papers scheduled are the following likely to be interesting to corrosion workers:

April 28

Chromate Conversion Coatings by C. W. Ostrander, Allied Research Products, Inc.

Metal Blasting and Finishing With Airless Blast Equipment by F. W. Pedrotty, American Wheelabrator & Equipment Corp.

April 30

Plastic Auto Body Developments by W. A. Hermonat, Naugatuck Chemical Div., U. S. Rubber Co.

Welding and Brazing High Temperature Materials by F. H. Stevenson, Aerojet-General Corp.

Corrosion Meetings—

(Continued from Page 16)

Nov.

13-18 The American Society of Mechanical Engineers, Congress & Hilton Hotels, Chicago, Illinois.

1956

Oct.

15-16 National Metal Exposition, Philadelphia, Pa. (A.G.A. will exhibit).

29 to Nov. 1 A.G.A. Annual Convention, Atlantic City, New Jersey.

Nov.

25-30 The American Society of Mechanical Engineers, Statler Hotel, New York, New York.

1957

Oct.

21-25 National Metal Exposition, Cleveland, Ohio (A.G.A. will exhibit).

Articles on meetings pertaining to corrosion control held anywhere in the world are welcomed for publication in CORROSION, NACE official monthly magazine.

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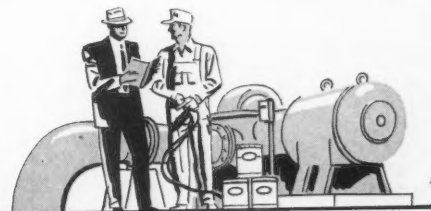


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- Firms seeking employees, regardless of NACE membership, may run an advertisement of the same specifications indefinitely.
- Advertisements to other specifications will be charged for at standard rates.

Positions Available

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Representatives or companies to handle additional established line corrosion resisting coatings and linings. Protected Territories available. Repeat business on established accounts. Extensive research facilities—strong office support. Carbo-line Co., 331 Thornton, St. Louis 19, Mo.

CORROSION CHEMIST

MS or PhD physical or electrochemist, 21-35, for corrosion research program of major midwestern petroleum refiner. Experience in corrosion research desirable but not essential. Program includes analysis and mitigation of plant corrosion problems, investigation of additives, inhibitors, etc., and fundamental work on corrosion reactions. Excellent laboratory facilities located near Chicago. Salary commensurate with training and experience. Please reply giving details of training and experience to CORROSION, Box 54-6.

SALES REPRESENTATIVE

Opportunity for recent chemical engineering graduate to specialize in plastic coatings in corrosion field work. Mechanical background would prove helpful. An excellent opportunity to get in on the ground floor of field corrosion service and grow with
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Positions Wanted

Corrosion Engineer—14 years' experience, last 7 with major non-ferrous alloy producer in service to chemical industry. Wants relocation North East with chemical or allied industry as plant corrosion or metallurgical engineer. CORROSION, Box 54-3.

R. M. Wick Is New ISCC Chairman

R. M. Wick, Bethlehem Steel Company has been elected chairman of the Inter Society Corrosion Committee succeeding H. P. Godard, Aluminium Laboratories, Ltd., Kingston, Ont., who has served during the past two years. Dr. Wick assumed office March 18.

N. E. Berry, Servel Inc., Evansville, Ind., and a past president of NACE has been elected vice-chairman to serve during the next two years.

ISCC Lists Sixteen Foreign Correspondents

Sixteen persons have been named foreign correspondents of the Inter Society Corrosion Committee to report each year to the committee about the corrosion work underway in their respective countries. The Inter Society Corrosion Committee, consisting of representatives of 35 United States and Canadian technical organizations is a function of the National Association of Corrosion Engineers. The sixteen delegates were selected as a result of the activities of the ISCC's sub-committee on Foreign Relations, of which F. L. LaQue, The International Nickel Co., Inc., New York, is chairman.

The foreign correspondents will be asked to supply the ISCC an annual report or survey of corrosion activities in their respective countries. It is expected also that these correspondents may be of assistance to foreign corrosion workers needing suitable direction to their counterparts in North America and in assisting corrosion workers from North America in their pursuits abroad.

The correspondents who have accepted the posts so far are:

Switzerland—Dr. E. Brandenberger, Professor of Chemistry Eidg. Technische Hochschule, Zurich.

France—Dr. G. Chaudron, University of Paris, Faculté des Sciences, 11, Rue Pierre Curie, Paris, 1e.

South Africa—Mr. W. J. Copenhagen, S. A. Council for Scientific & Industrial Research, Corrosion Unit, P. O. Box 668, Capetown.

Austria—Dr. Ing. F. Fitzer, Institut für Anorganische Chemische Technologie, VI, Getreidemarkt 9, Wien.

Japan—Dr. T. Fujiwara, Imperial Chemical Industries (Japan Ltd.) 435 Tokyo Hotel Building, Tokyo.

New Zealand—F. J. T. Grigg, Director, Dominion Laboratory, Dept. of Scientific & Industrial Research, P. O. Box 8018—Government Building, Wellington.

England—Dr. T. P. Hoar, Department of Metallurgy, University of Cambridge, Pembroke Street, Cambridge.

Positions Wanted

Corrosion Engineer, BS electrical engineering, graduate work at Harvard and MIT. Six years' experience design and field installation corrosion mitigation systems and pipe line coatings. Desires to relocate. CORROSION, Box 54-5.

Spain—Professor E. Jimeno, Institute Espanol de Oceanografía Alcala, 27, Madrid (Espana).

Denmark—Dr. E. Knuth-Wenterfeldt, Department of Metallurgy, Technical University in Copenhagen, Copenhagen.

Netherlands—Professor C. A. Lobry de Bruyn, Corrosion Institute T.N.O., Postbus 49, Delft.

Italy—Dr. R. Piontelli, Politecnico di Milano, 32 Piazza Leonardo da Vinci, Milano.

Belgium—Dr. Marcel Pourbaix, Centre Belge d'Etude de la Corrosion, 21, Rue des Crapiers, Brussels.

Germany—Dr. G. Schikorr, Chemische Landesuntersuchungsanstalt, Kienerstrasse 18, Stuttgart N.

Sweden—Dr. Gustaf Soderberg, Kullagardsvaegen 6, Saevadalen.

Australia—A. G. Sussex, Metallurgical Chemistry Group, Commonwealth of Australia, Defence Research Laboratories, Private Bag No. 4, P. O. Ascot Vale W. 2, Victoria.

Norway—Prof. A. B. Winterbottom, Department of Metallurgy, Technical University of Norway, Trondheim.

Ann Arbor Instrumentation Papers Are Scheduled

Among the papers to be presented during the May 24-27 Symposium on Instrumentation to be given by University of Michigan at Ann Arbor are the following:

Sampling and Analyzing Air for Contaminants in Work Places by Leslie Silverman, Associate Professor of Industrial Hygiene Engineering, Harvard University.

Instruments Specifically Designed for Atmospheric Pollution Evaluation by George D. Clayton, U. S. Public Health Service.

Proceedings of the meeting will be published in an illustrated encyclopedia-type book. Additional information can be obtained from Director, Continued Education, 109 South Observatory St., Ann Arbor, Mich.

Instrument Conference

The Third Annual Analytical Instrument Clinic will be held in connection with the First International Instrument Congress and Exposition at Philadelphia September 13-24. The Instrument Society of America is the sponsoring organization of both meetings.

Advance registrations may be made through Dr. Axel Peterson, Mellon Institute, 4400 Fifth Ave., Pittsburgh 13, Pa.

Unsolved Problems Listed

Among the suggested avenues for future research proposed in the pamphlet "Some Unsolved Problems" assembled by the Administrative Committee on Research of the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., is the following from the Advisory Committee on Corrosion: Mechanism of Stress Corrosion Cracking.

Copies of this booklet may be obtained free on request.

MIT Corrosion Course

A week's course in Corrosion to summarize the fundamental and recent advances in the field will be given at Massachusetts Institute of Technology June 21-25. H. H. Uhlig, professor of metallurgy will be in charge and special lecturers will include Milton Stern, Research Associate in metallurgy at MIT, W. Z. Friend and F. L. LaQue, The International Nickel Co., Inc.; L. P. Sudrabin, Electro Rust-Proofing Corp.; R. M. Burns, Bell Telephone Laboratories and Norman Hackerman, University of Texas.

Besides attending the lectures and demonstrations registrants will visit the Clapp Laboratories at Duxbury, Mass., on June 26. Tuition is \$100. Information and application blanks may be obtained from Summer Session Office, Room 7-103, MIT, Cambridge 39, Mass.

Fulbright Professor Sought by Denmark

A candidate for a Fulbright professorship at the Metallurgical Department of the Technical University of Denmark specializing in corrosion is being sought. The award, for 1954-55, pays expenses only abroad, plus certain tax credits.

The university wants to get the names of interested candidates capable of presenting a course of lectures on corrosion theory and practice for engineers already working in industry. The university has well-equipped laboratories and is a center of corrosion information pertaining to pipe lines, tankers and other ships, piping, hot water heaters and oil burners.

Persons interested in this are invited to write, giving necessary information to: E. Knuth-Winterfeldt, Professor, Head Dept. of Metallurgy, Technical University of Copenhagen, Denmark, Ostervoldgade 10, K.

French Corrosion Meet

Technical sessions on corrosion, paints, pigments and varnishes, analysis and testing and other subjects will be held during the Third Annual Salon of Chemistry and Plastic Materials at Paris, France, December 3-12 inclusive. It will be held at the Parc des Expositions, Porte de Versailles, and will include a large number of industrial exhibits.

Exhibits will include laboratory equipment, chemical products, chemical engineering and the plastics industry.

A third session of the Chemical Engineering Conference will be held concurrently.

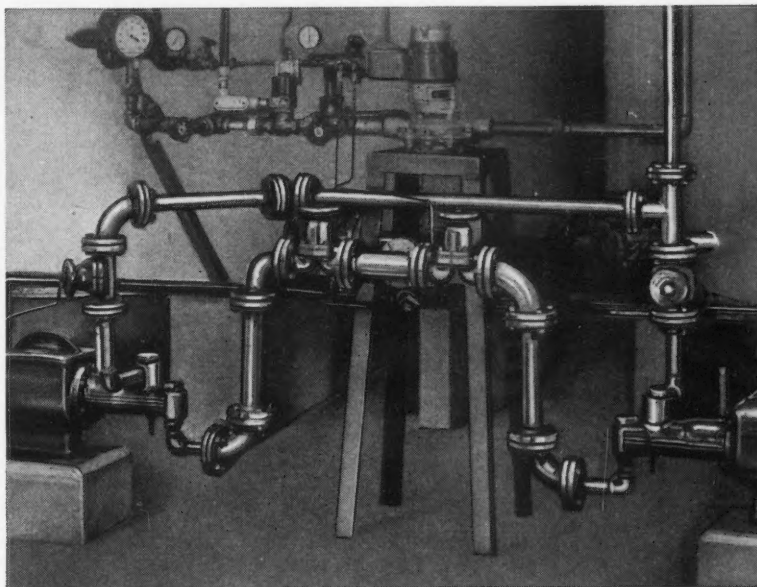
More information can be obtained from the Commissariat General, 28 Rue St., Dominique, Paris (7) France.

Electrodeposition Session

The Fourth International Conference on Electrodeposition and Metal Finishing will be held in London, England, April 20-24. Among the authors who will present 24 papers are U. R. Evans, T. P. Hoar, M. Simnad, and R. Piontelli.

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Joint tightness—unexcelled dependability
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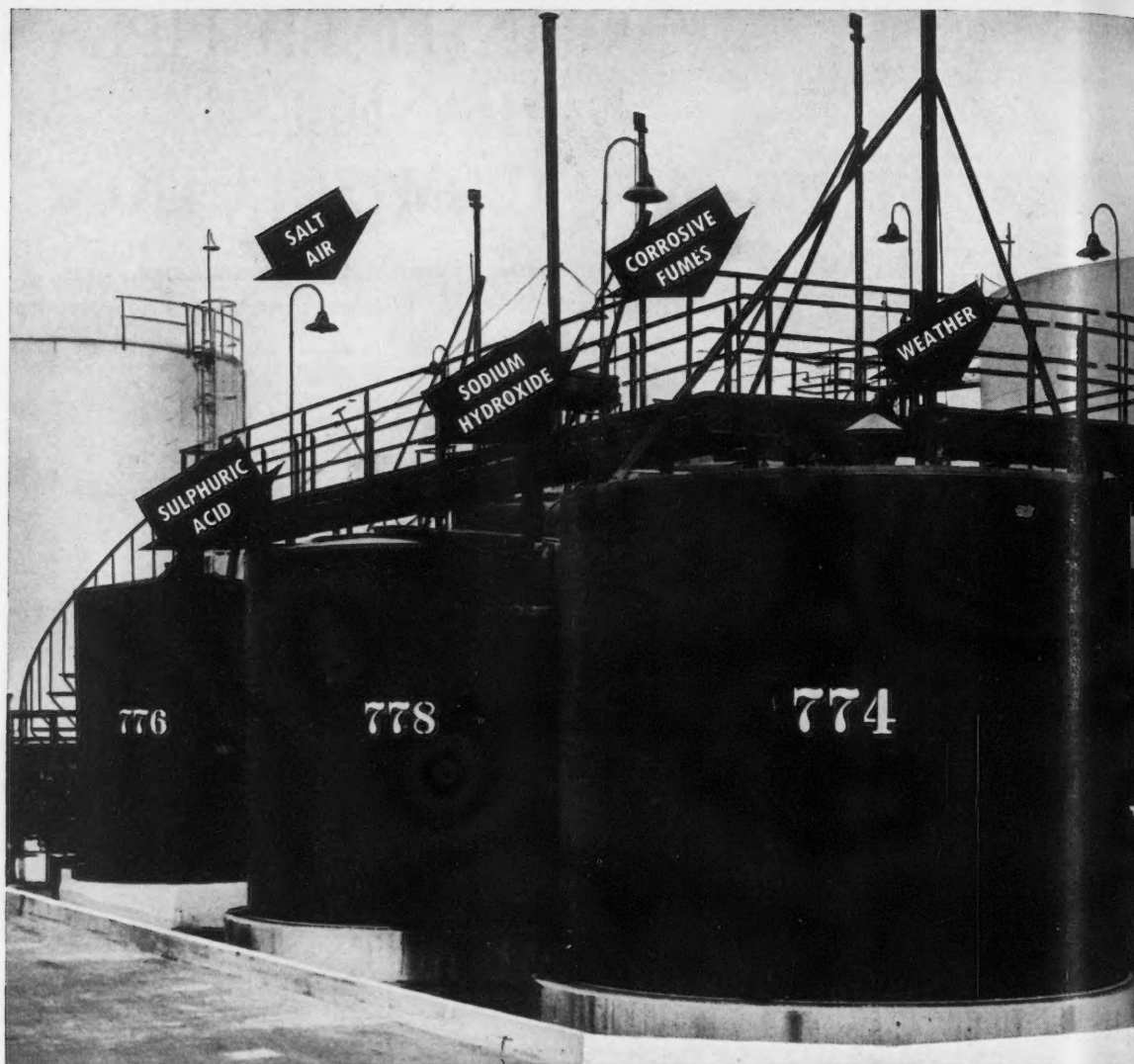
We'll be glad to assist with your installation plans. Write or call the SARAN LINED PIPE COMPANY, Ferndale 20, Michigan, or contact our nearest sales representative.

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Tank coatings by AMERCOAT. Amercoat Corporation, 4809 Firestone Boulevard, Southgate, California

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Corrosion used to eat away this oil company acid-plant equipment. Oil-base coating systems lasted only a few months. Then refinishing was needed. Heavy maintenance costs resulted.

A coating based on BAKELITE Vinyl Resins was recommended and applied. Well after two years, careful inspection showed that direct contact with sulphuric acid, sodium hydroxide, exposure to corrosive fumes, salt air and all types of weather had not affected the coating in any way.

There are many corrosion problems you can solve with coatings based on BAKELITE Resins. Investigate. You may find sizeable savings in plant maintenance.

Send for a free copy of the booklet,
"BAKELITE RESIN COATINGS FOR THE
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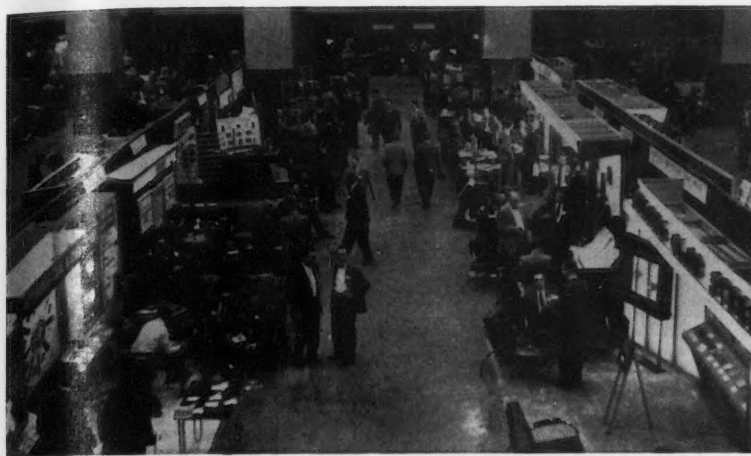
Write Dept. WX-69

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Much Praise Given Quality of K. C. Conference



AN AISLE AT THE EXHIBITION at Kansas City. Exhibitors were well pleased with the arrangement of the exhibition, the building in which it was held and with the cooperation they received from the operating personnel of the Kansas City Municipal Auditorium. Exhibition, technical sessions and a majority of the technical committee meetings were held in the auditorium.

Heavy Attendance At Technical Sessions Is Noted

Many more favorable comments were made on the quality of the Tenth Annual Conference and Exhibition at Kansas City than have been heard about any of the association's annual meetings in recent years. These comments were especially commendatory on the exhibition, which, because of the quality of the exhibits, the arrangement of the booths and the alertness of manufacturers' staffs, was said by many to have been the best so far arranged.

Heavy attendance at presentations of papers and at committee meetings both technical and standing was the rule. Interest at these sessions was so inclusive at some times that traffic in the exhibition section was reduced to a minimum. Arrangement of the exhibition, however, was such that most exhibitors were well pleased with results obtained.

Registration Is Down

Tentative registration figures released by Russell A. Brannon, NACE treasurer, showed there were about 100 fewer persons present in all than were present at the Chicago meeting. A substantial difference in the number of women's registrations, which reflected the relative attractions of Chicago vs. Kansas City, accounted for much of this.

Mr. Brannon's estimate was: Members and non-members, 1437; Exhibitors' guests, 537; Exhibitors, 86; Ladies, 71. Aggregate was 2131.

Overflow at Annual Dinner

The capacity of the grand ballroom at Hotel Muehlebach was exceeded by the number who attended the annual banquet. A side room off the ballroom had to be used to accommodate the diners. The Fellowship Hour was equally well attended by an estimated 1200 persons.

Presentations of NACE Awards to I. A. Denison of Diamond Ordnance Fuze Laboratories, Washington; E. H. Dix, Jr., Aluminum Company of America and of the 1954 Junior Author's Award to P. M. Aziz, Aluminium Laboratories, Ltd. Kingston, Ont. were features of the evening.

Hilarity attended the successful efforts of a light-fingered master of ceremonies who pilfered numerous articles from the persons of several willing guests during the entertainment which followed the presentations.

Ladies' Program

The program arranged for the visiting ladies included a tour of the city, a lecture and dance demonstration, a visit to the Nelson Art Gallery, a visit to the manufacturing plant of Hallmark greeting cards and a fashion show.

Exhibition Features 97 Companies' Products

Hackerman Favors Short Courses on Corrosion

Norman Hackerman, chairman of the National Association of Corrosion Engineers committee on education told members of the association's board of directors at Kansas City March 14 that he believes more good is accomplished by short courses on corrosion than by regular college curriculum courses. Dr. Hackerman, who is professor of chemistry at University of Texas based his opinion on the following factors: The emphasis today on a well-rounded technical education for engineers is sound. Any additions to the course of study would mean that some other study would have to be reduced to make a place for it. The engineer who goes into industry with an assignment in corrosion control can attend specialized short courses pertinent to his assignment to great advantage.

This opinion, he said, represents a change from what he formerly believed to be the best course for instruction on corrosion subjects.

Ryznar Is New Head Of Editorial Committee

John W. Ryznar, National Aluminate Corp., Chicago is the new chairman of the NACE Editorial Review Subcommittee. He succeeds T. P. May of The International Nickel Co., Inc., New York. Mr. Ryznar is a long-time member of the subcommittee which is responsible for the review of most of the material published in the technical section of Corrosion.

Ninety-seven companies displayed an absorbing array of corrosion control equipment, materials and instruments at the Kansas City Municipal Auditorium March 15-19 during the NACE Tenth Annual Conference and Exhibition. Registrants, exhibitors and exhibitors' guests were heard to comment favorably on the excellent presentations and the usefulness of the information available. As usual the booths were adequately staffed with well-informed representatives of the exhibiting firms.

Many exhibitors reported they were well pleased with the general arrangement of the exhibit floor and with the traffic flow this arrangement assured.

While, as usual at exhibitions sponsored by NACE there were many new firms represented, it was noted that a high proportion of firms with records of many prior participations were there. Some of these firms have participated in every exhibition NACE has held.

Prices on Bibliographic Survey Books Are Set

The following schedule of prices has been set by the NACE Board of Directors for copies of the Bibliographic Survey:

1948-49 volume: Members, \$10; non-members \$12.50.

1945-49 (3 volumes): Members \$18; non-members \$22.50.

1946-49 (2 volumes): Members \$16; non-members \$20.

Other combination and single volume prices were unchanged.

Articles on meetings pertaining to corrosion control held anywhere in the world are welcomed for publication in CORROSION, NACE official monthly magazine.

1958 Conference Is Scheduled for San Francisco



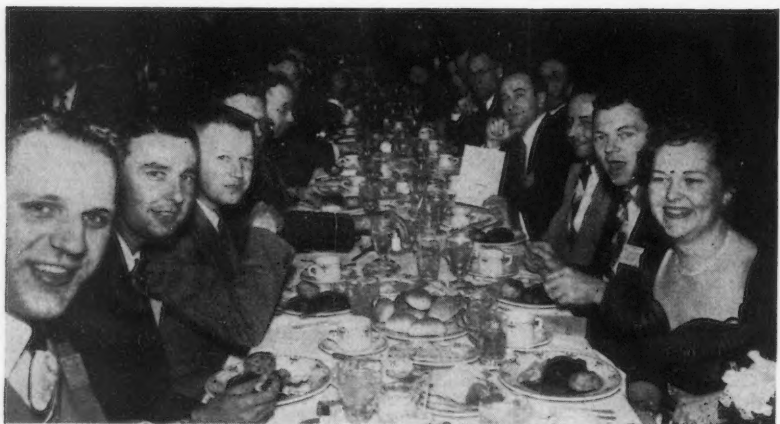
SOME OF THE COMMITTEE CHAIRMEN responsible for arrangement of the Tenth Annual Conference and Exhibition of the National Association of Corrosion Engineers are, in the customary order, C. C. Keane, Great Lakes Pipe Line Company, Kansas City, Local Arrangements Chairman; Harry K. Phipps, Socony-Vacuum Oil Co., Inc., Wichita, General Conference Committee Chairman; George A. Venneberg, Great Lakes Pipe Line Company, Assistant Chairman Local Arrangements Committee, and O. E. Murrey, Midwestern Engine & Equipment Co., Inc., Tulsa Exhibition Committee Chairman.



IRVING A. DENISON, Diamond Ordnance Fuze Laboratories, Department of Defense, Washington, D. C., is shown receiving the 1954 Willis Rodney Whitney Award from Norton E. Berry (right), Servel, Inc., Evansville, Ind. Presentation was at the March 17 annual banquet of the National Association of Corrosion Engineers, Kansas City. Mr. Berry was substituting for Mars G. Fontana, past president and chairman of the NACE Awards Committee. He is a past president also.



E. H. DIX, JR., Assistant Director of Research, Aluminum Research Laboratories, Aluminum Company of America, New Kensington, Pa., receives the 1954 Frank Newman Speller award from Norton E. Berry (right) Servel, Inc., Evansville, Ind. The presentation was made at the 1954 annual banquet of the National Association of Corrosion Engineers at Kansas City, March 17.



SOME OF THE OVERFLOW from the grand ballroom of Hotel Muehlebach who dined in an ell off the main room. Diners in the auxiliary room were not photographed in the panoramic picture taken of the dinner.

Provisions Readied For Division of Larger NACE Sections

San Francisco has been selected as the site for the 1958 Annual Conference and Exhibition of the National Association of Corrosion Engineers. The selection was made by the NACE board of directors at a meeting during the afternoon of March 14 at Kansas City, just before the opening of the association's Tenth Annual Conference and Exhibition. Walter F. Rogers, Gulf Oil Corporation, Houston, presided.

San Francisco was selected after the board heard a report from Vance N. Jenkins, Union Oil Company of California, Brea on the facilities available at several sites on the West Coast. Mr. Jenkins' report indicated clearly that facilities at San Francisco were superior to those available at other sites considered.

The board also took steps toward setting up procedures whereby sections of the association that wished to do so might divide themselves. E. P. Noppel, Ebasco Service, Inc., New York City, chairman of the association's policy and planning committee was asked by the board to prepare recommendations for this action by sections.

Numerous other matters were considered by the board and reports were heard from the chairmen of standing committees. These reports included those of Norman Hackerman, University of Texas, Austin, chairman of the association's education committee. Dr. Hackerman said he had received information from the University of Toronto and from the NACE Southeast Region concerning short courses during 1954. Six short courses were held during 1953 with co-operation of NACE, he reported.

Other actions included: The selling price of the 1948-49 Bibliographic Survey was set at \$10 to members and \$12.50 to non-members.

The time during which refunds will be made from corporate memberships to the association secured by sections was extended.

Appropriations to the Steel Structures Council of \$250 for 1953 and \$250 for 1954 were authorized.

Model rules and regulations for regions and sections were approved.



WALTER F. ROGERS (left) turns over the presidency of the National Association of Corrosion Engineers to Aaron Wachter (right) at the 1954 annual banquet of the National Association of Corrosion Engineers at Kansas City, March 17.



GUESTS AT THE FELLOWSHIP HOUR at Hotel Muehlebach, Kansas City, March 16. Top: Miss Jane H. M. Rigo, American Steel & Wire Company, secretary-treasurer of Cleveland Section, and W. W. Palmquist, National Carbon Company, Cleveland. Center: E. P. Noppel, Ebasco Services, Inc., New York, chairman of the NACE Policy and Planning Committee. Bottom: Left to right: R. A. (Bob) McCarthy, Hill, Hubbell & Co., Div. General Paint Co., Dallas; Mrs. Maynard Jackson, Tulsa, and N. A. Atchison, Hill, Hubbell & Co.



Overflow Crowd Attends Annual Banquet

An overflow crowd, which more than filled the grand ball room of Hotel Muehlebach at Kansas City enjoyed the 1954 annual banquet of NACE Wednesday, March 17. An entertaining pick-pocket and a master at repartee delighted the large and convivial audience which was characterized by a pleasantly large percentage of wives of registrants and other ladies.

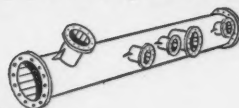
Among the distinguished guests, in addition to many of the association's past presidents and other officers was

Dr. Frank Speller, after whom the NACE Speller Award was named.

Norton E. Berry, Servel, Inc., Evansville, Ind. acted in place of Mars G. Fontana, NACE's immediate past president, in presenting the annual NACE awards to I. A. Denison and E. H. Dix, Jr.

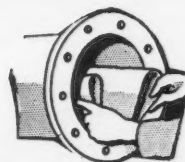
Norman Hackerman, University of Texas, Austin and chairman of the association's education committee presented the junior author award to P. M. Aziz, Aluminium Laboratories, Ltd., Kingston, Ont.

... efficient
economical answers
to your pipeline
corrosion problems!



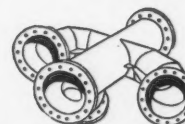
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36 Technical Committees Meet at Kansas City



F. N. ALQUIST (left) presides over a meeting of T-3C on Annual Losses Due to Corrosion during the NACE Tenth Annual Conference and Exhibition at Kansas City in March. Dr. Alquist is with Dow Chemical Company, Midland, Mich.



SPEAKER AND SPECTATORS DURING PRESENTATION of the paper "Effect of Design, Fabrication and Installation on the Performance of Stainless Steel Equipment," by James A. Collins, E. I. Du Pont de Nemours & Co., Ltd. This was the first paper of the 8-paper Chemical Industry Symposium presented at the Tenth Annual Conference of the National Association of Corrosion Engineers at Kansas City, March 17.

Improved Materials For Utility Industry Aim Of New Committee

Improvements in the corrosion resistance of materials and substitution of metals more corrosion resistant for those now specified for use in the utilities industries is the aim of newly-formed T-4F on Materials Selection for Corrosion Mitigation in the Utility Industry. The committee met at Kansas City March 17. David Hendrickson, East Bay Municipal District, Oakland, Cal. is chairman and Robert A. Ashline, Dept. of Water & Power, Los Angeles, vice-chairman.

Among the things the committee proposes to do are: Suggest ASTM Designation A 278 for cast iron valve bodies, as a better material than A 126 currently specified.

Suggest ductile Ni-resist bolts for service clamps.

Up-grade Grade I, ASTM B-62 by making nickel content 2.75% instead of the present 1%.

Substitute aluminum bronze for high zinc bronzes when dezincification is possible or substitute S and K Monel for bronze.

The committee has had reports corrosion troubles with water meters are increasing because of the down-grading of bronzes during the war.

Reports Are Readied For Publication; New Groups Are Formed

Meetings of 36 technical committees and subcommittees were held at the Municipal Auditorium, Kansas City, during the NACE Tenth Annual Conference and Exhibition. These included all-day sessions of some of the larger groups.

A new committee T-4F on Materials Selection for the Utilities Industry was announced and several changes of officers were made.

A decision of the board of directors authorizing the executive secretary to hire a technical committee secretary also was significant. It is anticipated this will materially expedite the completion of numerous projects and reports by the committees.

Two interim reports have been approved for early submission for publication by committees. These are T-4B-4 on Protection of Pipe Type Cables and T-2D on Standardization of Procedures for Measuring Pipe Coating Conductance.

T-3A on Corrosion Inhibitors will submit for publication a list of 68 classes of inhibitors compiled by the committee.

Change of Scope Voted For Committee T-2C

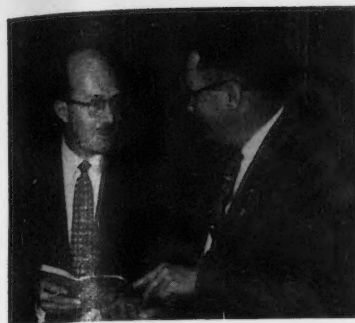
The scope of T-2C on Minimum Current Requirements has been changed as follows: To establish primarily the principles of minimum current requirements and the application of those principles for cathodic protection of all metallic structures in any environment. This decision was among those reached at a meeting of the committee over which L. P. Sudrabin, Electro Rust-Proofing Corp., Newark, N. J., chairman presided. Thirty-nine participated in the meeting held March 15 at Kansas City.

A nominating committee will suggest three candidates for the office of vice chairman.

Three reports were heard and discussed: Ray M. Wainwright, University of Illinois, Urbana presented a report which will be circulated among committee members. F. L. LaQue, The International Nickel Co., New York, said investigations of the polarization characteristics of mill scale showed mill scale as plus 0.235 volts versus a saturated calomel half cell in flowing sea water. Mr. Sudrabin also presented a report.

A task group to study criteria for protection was appointed with N. P. Peifer, Manufacturers Heat & Light Co., Pittsburgh, as chairman and a task group chairman will be named to lead the study of factors influencing minimum current requirements.

A report of last year's work by the committee was heard and questionnaires issued in the past by TP-4 and American Gas Association were studied with the result they were not approved for use by the committee.



NEW NACE OFFICERS discuss the technical program at the association's Tenth Annual Conference and Exhibition at Kansas City in March. Left, Aaron Wachter, Shell Development Co., Emeryville, Cal., and right, Frank L. Whitney, Jr., Monsanto Chemical Company, St. Louis, vice-president. They took office on the last day of the conference. Mr. Whitney was technical program chairman for the Kansas City meeting.

Tank Car Coating Data Discussed by T-3E

Additional data are being collected for additions to work already completed on three objectives of T-3E on Transportation. Work already done and the necessary additions were discussed March 15 at Kansas City at a meeting of the committee attended by 15. J. Robert Spraul, General American Transportation Corp., East Chicago, Ind., presided.

Expanded information in greater detail with particular reference to alloy compositions, coating thickness and average life is to be added to data already collected on field experience with protective coatings and construction materials used in tank cars. A suggested procedure for preparing the interiors of tank cars for lining has been compiled, but the committee decided to include additional information and requirements concerning tests of completed coatings.

A preliminary draft of a tank car cleaning chart has been prepared for consideration during the coming year.

Two Reports Are Made On Asphalt Type Coatings

Reports from two subcommittees of T-6L-1 on Asphalt-Type Pipe Coatings—Pacific Coast Region were presented at a meeting of the committee March 17 at Kansas City. Nineteen members, with R. J. Schmidt, California Research Corp., Richmond, Cal., chairman presiding, heard recommendations of subcommittee 1 concerning the Asphalt Institute's specifications on asphalt coatings. After discussion it was agreed the committee will prepare a composite of agreements and disagreements with these specifications in an attempt to resolve the differences.

Subcommittee 2 reported progress in recommending criteria to be used in reporting on and evaluating the performance of asphalt-type coatings. After discussion form of procedure and inquiry to be made of industry for reports on performance was agreed on.

Coating Conductance Interim Report Readied

Immediate minor correction of a revised draft of an interim report of T-2D on Standardization of Procedures for Measuring Pipe Coating Conductance and its presentation for publication have been decided on. This decision was reached at Kansas City March 15 at a meeting of 39 committee members with Wm. E. Huddleston, Huddleston Engineering Co., Bartlesville, Okla.

Mr. Huddleston was reelected chairman and L. F. Heverly, Kansas City, was named vice-chairman.

Write to NACE, 1061 M & M Bldg, Houston, for information on publications.

Reports Are Given on Neoprene Jacket Tests

Results of tests on neoprene jackets over lead cables were presented at the March 15 meeting of T-4B-5 on Non-Metallic Sheaths and Coatings at Kansas City. George H. Hunt, Simplex Wire & Cable Co., Cambridge, Mass., chairman, presided.



Tests during the past year, it was reported, have shown that neoprene jackets over lead failed in two to three months at 90 volts DC negative on the lead. Further investigations at intermediate voltages are to continue.

H. M. Clayton of Memphis Light, Gas & Water will send in results of voltage tests on protective tapes.

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Interim Report on Pipe Type Cables Due Soon On Survey by Technical Group T-4B-4

Recommendations Drafted On Aluminum Preparation

A draft of a proposed series of recommendations for surface preparation of aluminum prior to application of coatings has been prepared. The draft will be circulated among members of NACE Technical Committee T-6G for criticism. A revised draft will be prepared, probably for consideration at the 1955 NACE Eleventh Annual Conference to be held at Chicago. If approved there it will be forwarded as a report of the committee for approval and publication.

The committee, at its meeting March 15 at Kansas City, also planned a task force to prepare specifications for surface preparation of magnesium. Persons interested in the subject are invited to write to the committee chairman for more information.

Emphasis Needed on Proper Application Is Coating Group's Belief

More emphasis on proper application is needed to get the best results from protective coatings, it was decided at a meeting of T-6E at Kansas City March 16. Jack P. Barrett, Stanolind Oil and Gas Co., Tulsa and Joe Robertson, Phillips Petroleum Co., respectively outgoing and incoming chairmen presided. There were present 5 members and 14 visitors.

Data received on the tank coating questionnaire were presented in a tabulated summary.

Discussion on the future aims of the committee developed the following possible avenues of inquiry: A specification of code for coatings application. Minimum equipment requirements for coating applications. A guide for coating inspectors and a suggested maintenance practice to get most out of coatings longest at least cost.

List of 68 Classes of Inhibitors Is Approved

A list of 68 classes of inhibitors compiled by members of T-3A on Corrosion Inhibitors has been approved and will be submitted for publication. This decision was reached at the committee's March 17 meeting at Kansas City attended by 26 members, with R. S. Wise, National Aluminate Co., Chicago, chairman, presiding.

A subcommittee was named to recommend the basis of organizing task groups.

Messrs. Wise and J. L. Wasco, The Dow Chemical Co., Midland, Mich. were reelected chairman and vice-chairman.

An interim report will be prepared for early publication by T-4B-4 on Protection of Pipe Type Cables. This decision was reached at a meeting of 57 committee members at Kansas March 15. Frank Kahn, Philadelphia Electric Company, presided. The committee has compiled a 60-page volume of detailed replies and summaries of replies to a questionnaire circulated earlier. The summaries are to be used in the interim report.

Participants in the questionnaire will be encouraged to exchange information, with copies to the committee chairman. An example of the value of this activity was the reading of a letter and reply on the subject of gaps for isolating the pipe from ground. A lively discussion on the use and types of these gaps and the safety hazards inherent followed.

Western Kansas Well Corrosion Is Revealed

Detailed reports on corrosion in wells in Western Kansas were given members of T-1D at its meeting at Kansas City March 17. Brief reports by committeemen on results obtained by inhibitor injection programs of their respective companies were also given. The committee, on Sour Oil Well Corrosion, also discussed a committee-wide investigation of factors involved in pump corrosion.

J. A. Caldwell, Humble Oil & Refining Co., Houston, presided and 51 were present.

T-4C Group Meets

Results of the information summary from the committee's questionnaire were discussed March 15 at a meeting of T-4C on Stray Railway Current Electrolysis during the NACE Conference at Kansas City. A distribution of the final form of these results was made to members at the meeting presided over by M. D. Fletcher, Illinois Bell Telephone Co., Chicago. There were 54 present.

New Officers Preside At Permian Session

New officers of the Permian Basin Section presiding over their first Section meeting pledged their efforts toward making their Section a bigger and better one. For the technical program, John C. Watts, Humble Pipeline Co., Midland, Tex., spoke on "Internal Plastic Coatings in Pipelines in Place." Many expressed the opinion that Mr. Watts presented an exceptionally good paper. He was kept at the rostrum for about an hour answering questions. Among the 69 persons attending were the following guests: A. E. Crouse, and L. W. Miller, Continental Oil Co., Ft. Worth, Tex.; and Arno Anders, Continental Oil Co., Midland, Tex.

Uhlig Addresses Joint Meeting at Detroit

In a joint meeting Feb. 25, with the Electrochemical Society, members of the Detroit Section, of the National Association of Engineers heard H. H. Uhlig speak on "Corrosion as an Electrochemical Process."

Dr. Uhlig, long prominent in the field of corrosion investigative research, covered briefly: pitting, dezincification, intergranular corrosion, corrosion fatigue and types of corrosion cells. He then discussed various corrosion control methods such as cladding metals, coatings, cathodic protection, alloying, metal purification, peening and other control systems. He used slides to illustrate his talk. The 175 persons avidly questioned their prominent speaker. Section officers did not schedule a March meeting.

For the April 21 meeting, Section members and guests will hear another widely known expert on corrosion, Frank LaQue, The International Nickel Co., will speak on "The Impact of Corrosion on Everyday Life." The meeting will be held at the Engineering Society of Detroit banquet hall. It will be a joint meeting with the Engineering Society of Detroit and an attendance of between 500 and 700 persons is expected. Mr. LaQue will supplement his talk with illustrations, displays and exhibits.

Plastic Tapes Is Topic of St. Louis April Meeting

"Plastic Tapes as Corrosion Control Coatings," by Howard D. Segool, The Kendall Co., Chicago, Ill. will be the technical subject for the April 12 meeting of the Greater St. Louis Section. The May 10 Section meeting will hear E. D. Weisert, Haynes Stellite Co., Kokomo, Ind. speak on "High Alloy Corrosion Resistant Materials."

Members and guests attending the March 8 meeting heard Sol M. Gleser of the Upper Mississippi Valley Division of the Corps of Engineers talk on "Modern Paints are Engineering Materials." From a background of 23 years service with the Corps of Engineers, Mr. Gleser spoke on the history and development of standard paint coatings by the Corps of Engineers. He placed particular emphasis on the use of vinyl paints and phenolic fortified oleoresinous paints for the protection of underwater surfaces of locks, dams, and the like.

Vancouver Section Meets

"Considerations of Design and Selection of Materials To Avoid Corrosion," was the technical subject scheduled for the March 23 meeting of the Vancouver Section, with R. J. Law, The International Nickel Co. of Canada, Ltd. the speaker. Mr. Law is the Canadian Regional Director of The National Association of Corrosion Engineers. Arrangements were made to hold a joint meeting with the Chemical Engineering Division, Chemical Institute of Canada, Vancouver Section.

NEW PRODUCTS — Materials — Service — Literature

Central Research Laboratories, Inc., Red Wing, Minnesota, is making a High Temperature X-ray Diffraction Powder Camera Model HC-101 designed for general purpose investigations of substances at controlled elevated temperatures up to 1000 degrees C. The movable film carrier allows five 7-mm diffraction patterns to be made on the same film. Coiled helix furnace heating elements are of platinum-rhodium.

Grit-Like Material anchored in neoprene bonded to concrete, wood or metal floors gives a skid-proof surface highly resistant to fumes, spillage from acids, alkalis, salt solutions and solvents at temperatures up to 220 degrees F. Pennsylvania Salt Manufacturing Co., 1000 Widener Bldg., Philadelphia 7, calls the material Neofloor. Primer and coating are liquids.

Heil Process Equipment Corp., 12901 Elmwood Ave., Cleveland 11, is producing two new lines of corrosion resistant exhaust blowers. One, with capacities from 300 to 7000 cfm is for simple ventilating or mildly corrosive conditions while the other, rated from 750 to 54,000 cfm, is for more severe service. Smaller units are coated with phenolics, vinyls or rubber and the larger units with natural or synthetic rubbers.

A Liquid Fuel type atomic reactor of 100 kw capacity has been designed for construction anywhere in the United States by The Babcock & Wilcox Co. It uses demineralized light water as coolant and concentrated uranyl sulfate as fuel. Cost is said to be much lower than any previous comparative reactor.

Cemented Carbide pieces as heavy as 4000 pounds can be produced in a new 220-ton hot press installed recently in the Carbology Dept., of General Electric Company.

Shell Chemical Corporation's epoxy resin plant recently brought on stream at Houston will triple the company's supply of epon resins. The company opened simultaneously a bis-phenol-A plant, making the company independent of outside suppliers for this component of the epons.

Hamer 10 and 12-inch balanced-type plug valves in ASA 150-lb. and 300-lb. classes are being made by Hamer Oil Tool Co., 2919 Gardenia Ave., Long Beach, Cal. The gland-packed valves are intended for high and low temperature service.

Okonite-Callender Cable Co., Inc., a wholly-owned subsidiary of the Okonite Co., Passaic, N. J., has been merged with the parent company.

Non-Magnetic, spark-resistant and corrosion resistant one-ton chain hoists are now being made by Ampco Metal, Inc. With exception of a few non-metallic parts and Monel ball bearings the Unit is made of Ampco special copper-base alloys. They are designed for use in hazardous areas and where corrosion is possible from liquids or fumes.

Heat Exchangers to handle corrosives with tubes fabricated of tantalum, Karbate, stainless steel, nickel and black iron are manufactured by Carl Buck & Assoc., P. O. Box 267, Essex Falls, N. J.

Du Pont Products for Industrial Radiography, giving exposure and processing data for the company's industrial films is a guide for X-raying such metals as steel, magnesium and aluminum. The 28-page, 3-color booklet is available from Du Pont Photo Products Dept., Wilmington 98, Del.

Fiberglass Products for Papermaking, a 21-page booklet available from Owens-Corning Fiberglass Corp., 16 East 56th St., New York 22, N. Y., unveils research dating to 1937 on the use of Fiberglass papers for filtering airborne radioactive dusts or particles from corrosive liquids.

Empire Steel Castings, Inc., Reading, Pa., has issued Bulletin 253-LA relating to the company's Isocast carbon and low alloy castings to ASTM, Federal, Navy, AISI and SAE specifications.

Toranil, a sugar-free calcium lignosulfate, virtually non-hygroscopic, is available as a solution or as a powder. It is being used as a dispersant wetting agent, in adhesives, remoistenable tapes, resin extenders, emulsifiers and otherwise. Lake States Yeast Corp., Rhinelander, Wis., is the producer.

Heavy Wall extruded Saran tubing, size 2 3/8-inch OD by 1 1/2-inch ID in 3-foot lengths is manufactured by Pyramid Plastics, Inc., 554 W. Polk St., Chicago 7, Ill.

Allegheny Metal stainless steel for use in the paper industry is described in a booklet "Allegheny Metal in the Paper Industry" available from Advertising Dept., Allegheny Ludlum Steel Corp., 2020 Oliver Bldg., Pittsburgh 22, Pa.

Kel-F Welded Membrane, a 4-page brochure describing the technique of lining tanks with a sandwich consisting of a Kel-F bag inside a vinyl bag, with a third vinyl bag inside the Kel-F bag is available from United States Stoneware Co., Akron, Ohio. The Kel-F bag is made outside the tank with outlets built in. Seams are electronically welded. The three-layer bag is inserted and then oversheathed with acid-brick and cement. Factory or field installation is possible.

Polyethylene pellets will be produced at a plant to be built soon by Koppers Company's Chemical Division. Several plant sites are under consideration.

Alloy GR40A (ASTM designation), is now accepted for use in unfired pressure vessels by the Boiler Code Committee of ASME. The aluminum alloy has higher mechanical properties than those previously used for welded pressure vessels. It is superior to the others for high temperature operations.

Solubility Factor in Metal Phosphate Pre-Treatments, by Max Kronstein, Philip Hixon and Jack Granowitz, of the College of Engineering, New York University, University Heights, New York, has been reprinted and is available for 35 cents a copy from the college's Office of Information Services. It appeared originally in Paint and Varnish Production, Vol. 43, No. 12 (1953) Dec.

T-Film, a Teflon-base thread sealing compound made by Eco Engineering Co., Chemical Products Div., 12 New York Ave., Newark, N. J., can be supplied now with added pigments such as graphite, molybdenum sulfide, lead or copper. The compound, while giving proper seal, permits joints to be broken when necessary without galling or sheared threads.

Fluoroflex-T hose and pipe, products of Resistoflex Corp., Belleville, N. J., made from Teflon are now available. Pilot plant production of hose for jet engine lubrication uses is now under way.

Binks Manufacturing Co., 3122 Carroll Ave., Chicago 12, Ill., is holding spray painting schools during the weeks of May 3-7 and June 7-11. There is no tuition but students pay all transportation and other expenses. Applications should be made at once.

Chemi-Spot, a kit permitting identification of more than 80 of the commonly used metals and alloys is available from Wescott Laboratories, Elizabethtown, N. Y. The 12-pound kit is equipped with all necessary materials except concentrated acids.

Aluminum on the Skyline, a 28-minute 16-mm sound and color motion picture showing the 30-story Alcoa building in Pittsburgh is available for showing on application to Alcoa Motion Picture Dept., 722 Alcoa Bldg., Pittsburgh 19, Pennsylvania.

A Comparative Evaluation of the Performance of Certain Protective Coating Systems in Severe Hydrochloric Acid Atmosphere, a report on tests conducted for Gates Engineering Co., Wilmington, Del., by Kenneth Tator Associates shows the results of exposures of various synthetic resin, coal tar and other coatings by illustrations. The test panels, including welded projections, illustrate the condition of the coatings at exposures ranging from 8 to 83 weeks.

Rise Water from a steel pickling operation is being discharged into a waste bed from a 3-inch Tenite butyrate pipeline 2400 feet long. The water is pumped at 165 foot head pressure. Busada Manufacturing Corp., Maspeth, N. Y., extruded the pipe.

A Porcelain Coated smokestack has been erected to serve the Crippled Children's Hospital at New Orleans by Seaport Metals, Inc.

(Continued on Page 28)



"PUTTING
Permanence
IN PIPE"

CLEANING, COATING, WRAPPING & RECONDITIONING

HOT DOPE

Straight from the Kettle
on PIPE PROTECTION

By Boyd Mayes

• Saw some place recently where one of those Oil writers said: "PIPELINING IS EVERYBODY'S BUSINESS." With this, we surely agree. We're not talking about just the side he was adding up—we're talking about the human side—how much benefit that gas pipelining has brought to all of us. Reckon there's a whole new generation growing that will never know what it is to chop kindlin' and tote wood for a kitchen stove or fireplace. They'll just light a match—turn on the gas—and there she glows—thanks to good pipelining—and progress. Another interesting thing recently noted is the amount of chemical pipelining. Folks would be surprised how much butadiene, styrene, chlorene, propylene, etc. pipelines carry under the Texas Gulf Coast. Yes, pipelining is big business and we are happy to be a part and offer our facilities to everyone who needs coating, wrapping and reconditioning service for pipe. We've been at it 26 years and have the best men in the business to handle it.

MAYES BROS.
1150
McCurry
HOUSTON, TEXAS
Oil chd
7546

NEW PRODUCTS

(Continued From Page 27)

Atlas Mineral Products Co., Mertztown, Pa., has published and will distribute on request a 50-page booklet describing protective coatings on a generic basis. Two courses for corrosion engineers will be given by the company, one in April and the other in September on stress selection, design, testing and application of plastic materials for construction.

Bulletin No. 56, a reprint issued by Buffalo Electro-Chemical Co., Inc., describes a new series of vinyl plasticizers, epoxy fatty acid esters. The bulletin is a summation of results of laboratory studies which prove that epoxy fatty acid esters can be derived from abundant cheap fatty raw materials. Polyvinyl chlorides formulated with these esters possess outstanding heat and light stability even in the absence of added conventional stabilizer, the company claims.

Stability of Hydrogen Peroxide in concentrations above 90 percent by weight is described in Bulletin No. 55, a reprint, now available from Buffalo Electro-Chemical Co., Inc. A method of determining stability said to be superior to the elevated-temperature and room-temperature standing test is described.

Sonogen, Model 500 Ultrasonic-Power Generator, made by Branson Instruments, Inc., 430 Fairfield Ave., Stamford, Conn., is designed primarily to speed cleaning and degreasing of small parts and metal objects. The radiofrequency output is 500 watts at 450,000 cycles per second. In use the vibrations are transmitted to cleaning fluids in which parts to be cleaned are immersed. The device also can be used in emulsification, dispersion and in accelerating chemical reactions.

Problems of Corrosion and neutron damage are yet to be solved by The Babcock & Wilcox Company's Atomic Energy Division in designing a reactor for a proposed atomic powered locomotive.

Metallizing Engineering Co., Inc., is building a new 65,000-square-foot plant at Westbury, Long Island.

Ace Durador, a steel reinforced plywood door covered with a tough hide of soft hubber is recommended for use in plants where corrosives are present by American Hard Rubber Co., 93 Worth St., New York 13, N. Y.

A New Dry-Charge storage battery manufactured by Gould-National Batteries, Inc., may be kept dry in storage for long periods without deterioration and is quickly readied for use after filling with the usual acid solution. It will eliminate the need for charging facilities in many instances.

"S" Monel's engineering properties are described in a booklet that has been issued by the Development and Research Div. of The International Nickel Co., Inc., 67 Wall St., New York 5, N. Y. Copies are available from the company's Technical Service Section.

PERSONALS

Harry B. McClure has been appointed president of Carbide and Carbon Chemicals Company, a Division of Union Carbide and Carbon Corp.

Robert F. Huntton has been appointed associate director of physics at the National Bureau of Standards.

Richard H. DeMott, president of SKF Industries, Inc.; James L. Myers, president of Clevite Corp., Cleveland and Ralph J. Cordiner, president of General Electric Company received the Stevens Honor Award Medallion at the 84th annual dinner of the Stevens Institute of Technology Alumni Association.

R. E. McNeill, Jr., has been elected a director of American Smelting and Refining Co.

E. T. Wilson, Jr., sales representative of Babcock and Wilcox Tubular Products Div., died unexpectedly February 24.

A. B. Drastrup has been elected executive vice-president of A. M. Byers Company.

Warren C. Lothrop has been appointed a vice-president of Arthur D. Little, Inc.

James Smith has been transferred from Lithcote Corporation's New York office to its Norwalk, Conn., plant as chemical engineer.

Harold C. Templeton has been named chief metallurgist, **Ray W. Partridge** is now service manager and **Roy W. Daub** is chief planning engineer for Lebanon Steel Foundry, Lebanon, Pa.

John G. Fleming has been named product planning manager of The Bristol Company, Waterbury, Conn.

Raymond B. Seymour has been named president of the Atlas Mineral Products Company. He joined the firm as chief chemist in 1939.

Robert J. Johnson has joined the Pittsburgh Technical Section of The International Nickel Company's Development and Research Division.

Stanley G. Benner has joined the Ceramic Coating Dept., Chemical Equipment Division, General Ceramics and Steatite Corp., Keasbey, N. J.

R. L. Kittle, superintendent of Shell Chemical Corp., Houston plant, has become manager of the company's manufacturing operations department, New York City. **Glenn Purcell** has been transferred from the Dominguez, Cal., plant to become manager of the Houston plant, replacing **B. M. Downey**, recently transferred to New York as manager of manufacturing.

Littleton C. Barkley, 51, general sales manager, West Coast Div., Raybestos-Manhattan, Inc., died in August at San Mateo, Calif. Twenty-seven years ago, Mr. Barkley joined the Manhattan Rubber Mfg. Co., Passaic, N. J., now the Manhattan Rubber Div of Raybestos-Manhattan, Inc.



Corrosion Abstracts

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1. GENERAL

1.1 Miscellaneous

1.1 Outstanding Dates in the History of the Prevention of Corrosion to 1935. G. SEELMEYER. *Werkstoffe u. Korrosion*, 4, 14-19 (1953) Jan.

Indicates development of conception of corrosion prevention from Roman times to 1935. Does not claim to be complete, but rescues much from oblivion and, at the same time, shows that many ideas presented as being new have already been advanced.—INCO. 6148

1.2 Importance

1.2.2 What Corrosion Cost Canada. *Canadian Metals*, 16, No. 7, 8 (1953) June. Conservative estimates place cost of corrosion in Canada at \$300,000,000 annually. Many factors are left out where figures were not available, so actual cost would be well above the figure given. Details given of cost of corrosion protection and wear of domestic appliances and internal combustion engines. Table is shown.—INCO. 6279

1.3 Reviews

1.3.5,4.5, 5.4.7 Recent Developments in the Field of Organic Protective Coatings. *Ind. Finishing (Brit.)*, 5, No. 55, 426-435 (1953). A review of materials and techniques

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Neither NACE nor the sources listed below furnish reprint copies.

AER—Aeronautical Engineering Review, Institute of Aeronautical Sciences, Inc. 2 East 64th St., New York 21, N. Y.
ALL—The Abstract Bulletin, Aluminum Laboratories, Ltd. P. O. Box 84, Kingston, Ontario.
AWWA—Journal, American Water Works Association, Amer. Water Works Assoc., 521 Fifth Ave., New York 17, N. Y.
BL—Current Technical Literature, Bell Telephone Laboratories, Inc., Murray Hill, N. J.
BTR—Battelle Technical Review, Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.
BNF—Bulletin; British Non-Ferrous Metals Research Association, 81-91 Euston St., London NW 1, England.
CALCO—Calco Chemical Division, American Cyanamid Corp. Bound Brook, New Jersey.
CE—Chemical Engineering, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.
CEC—Consolidated Edison Co. of New York, Inc. 4 Irving Place, New York 3, New York.
EL—Electroplating, 83/85 Udney Park Road, Teddington, Middlesex, England.
EW—Electrical World, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.
GPC—General Petroleum Corp. of California. 2525 East 37th St., Los Angeles 11, Calif.
IIM—Transactions, The Indian Institute of Metals, 23-B, Notaji Subhas Road, P. O. Box 737, Calcutta, India.
INCO—The International Nickel Co., Inc. 67 Wall Street, New York 5, New York.
IP—Institute of Petroleum. 26 Portland Place, London W.1, England.
JSPS—Japan Society for the Promotion of Science, Address: Mr. Hayata Shigeno, Secretary, Committee of Preventing Corrosion, c/o Government Chemical Industrial Research Institute, 1-Chrome Nakameguro, Meguro-ku, Tokyo, Japan.

MA—Metallurgical Abstracts, Institute of Metals, London, England. 4 Grosvenor Gardens, London SW 1, England.
MI—Metallurgia Italiana, Associazione Italiana di Metallurgia, Via S. Paola, 10, Milano, Italia.
MR—Metals Review, American Society of Metals. 7301 Euclid Ave., Cleveland 3, Ohio.
NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 38, Illinois.
NBS—National Bureau of Standards, Supt. of Documents, U. S. Gov't Printing Office, Washington 25, D. C.
NSA—Nuclear Science Abstracts, United States Atomic Energy Commission, Technical Information Division, Oak Ridge, Tenn.
PDA—Prevention Deterioration Abstracts. National Research Council, 2101 Constitution Ave., Washington 25, D. C.
RA—Refrigeration Abstracts, American Society of Refrigeration Engineers. 40 West 40th St., New York 18, N. Y.
RM—Revue de Metallurgie, Paris, France, 5 Cite Pigalle, Paris (9e), France.
RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London, Waldegrave Rd., Teddington, Middlesex.
SE—Stahl Und Eisen, Verlag Stahlisen, M. B. H., Dusseldorf, August-Thyssen Str. 1. Postcheck Köln 4110, (22a) Dusseldorf, Germany.
TIME—Transactions of Institute of Marine Engineers, 85 The Minories, London EC 3, England.
UOP—Universal Oil Products, 310 South Michigan Ave., Chicago, Illinois.
ZDA—Zinc Development Association, Lincoln House, Turl Street, Oxford, England.

which have more recently become available. The former include alkyd and silicone resins, urea formaldehyde and melamine combinations, as well as coatings of the vinyl, neoprene or chlorinated rubber type. New methods of application include hot-spray painting, the use of super-heated steam, controlled withdrawal dipping and electrostatic and roller coating methods.—EL. 6122

1.5 Directories of Material

1.5.1.6

Metallurgy. Ed. 65. (In French). R. CAZAUD. Book, 372 pp., 1953. Dunod, 92 Rue Bonaparte, Paris 6, France.

Condensed pocketbook of metallurgical information covers some 30 metals, briefly giving their properties, basic qualities, and metallurgical characteristics. Separate sections are devoted to metal corrosion, heat treatment and testing. Data tables and common formulas are included.—MR. 6273

1.5.3.5, 6.2.5

Design Considerations for Heat and Corrosion-Resistant Castings. E. A. SCHOEFER. Alloy Casting Inst. *Machine Design*, 24, No. 9, 148-154 (1952) Sept.

Cast high alloys available in a standardized range of compositions for wide application in heat and corrosion resistant service. These alloys are discussed in relation to their characteristics, properties and applications. The heat-resistant cast alloys are divided into three groups: Straight chromium (Types HC and HD), iron-chromium-nickel (Types HE, HF, HH, HI, HK and HL), iron-nickel-chromium (Types HT, HU, HW and HX). Corrosion-resistant cast alloys are divided into three groups: straight chromium (Types CA, CB and CC), iron-chromium-nickel (Types CE, CF, CG, CH, CK) and iron-nickel-chromium (Types CM, CN and CT). Nominal compositions of both A.C.I. and ASTM types are given. Table.—INCO. 5879

1.5.3.5, 8.4.3, 8.8.1, 3.7.2

High Temperature Service. R. M. BRACA AND R. MERIMS. *Chem. Eng.*, 60, 165-169+ (1953) Feb.

Comprehensive survey to aid in selecting materials and designing equipment for high-temperature service in petroleum and chemical plants. Includes influence of alloying elements and mechanical properties of metals used.—MR. 6220

1.5.8.8.1, 5.4.5

Protective Coatings—15th Materials of Construction Report. K. TATER. Kenneth Tator Associates. *Chem. Eng.*, 59, No. 12, 143-190 (1952) Dec.

Report includes how protective coatings fight corrosion, sound painting program can slash costs, organic materials vs. corrosion, each basic type has its own appeal, from material selected to job inspection, your guide to chemical resistance, directory of trade names and producers and materials of construction. Formulations suitable for chemical plant maintenance fall into a relatively few resin types: Natural rubber, synthetic rubber, neoprene, phenolics, furanes, epoxy, resins, oleo-resinous materials, vinyls, vinylidene chloride copolymers, chlorinated rubbers, styrene-butadiene resins, polyethylene, greases and waxes and bitumens. The table giving corro-

sion resistant materials of construction includes the manufacturer, description of the material and the most important applications of metals and alloys (many containing nickel), cement, ceramics, plastics, refractories and rubber. Graphs.—INCO. 5883

1.6 Books

1.6

An Engineer's Approach to Corrosion. C. F. TRIGG. Book, 133 pp., 1952. Sir Isaac Pitman and Sons Ltd., London.

The subject chosen by the author deserves accurate treatment in a small book of this character for wide circulation and one must admire the temerity of a writer who tackles the problem of corrosion. Had he been a member of all the corrosion committees and sub-committees which have studied the various aspects of the nature and prevention of the innumerable varieties of corrosion, he would perhaps have been lost in the forest of facts.

The reader will not find the book up to date and it would, for example, have been more helpful to refer to the 1948, third edition, instead of the 1939, second edition, of a book mentioned in the bibliography. The inaccuracies regarding alloys will annoy metallurgists.

The reference to information on marine-boiler corrosion could be made of practical value by stressing the revolution brought about by the practice of marine-boiler water-treatment according to B.S.1170. Similar reduction in the internal corrosion of land boilers is to be gained by adherence to a similar code. Engineers must be taught that smoke abatement and a reduction of the sulfur content of the atmosphere can save their products in much the same way as water treatment saves boilers from corrosion.

Although reference is made in the bibliography to certain books and papers, it is a pity that the practical engineer has not been directed to the specialist periodicals such as CORROSION and others which are referred to in so many corrosion abstracts to be seen in the JOURNALS of the Iron and Steel Institute and the Institute of Metals. The engineer who seeks to go deeper into problems of corrosion should study those abstracts to bring up to date the eight chapters of this book, for there are many varieties of engineers and the corrosion problems they meet are equally varied under the influences of temperature, atmosphere, abrasion, erosion and condensation.

The book will serve a good purpose if it leads readers to the BISRA Corrosion Committees' researches, the BNFMR's reports, the discussions of the Society of Chemical Industry "Corrosion Group" and to the day-by-day prevention of corrosion in practical engineering.

Discusses: Mechanism of corrosion, corrosion under special conditions, effect, prevention, preparation for corrosion proofing, permanent and temporary treatments.—MA. 5858

1.6.5.5.3

Corrosion and Temporary Protectives. Shell-Mex and B. P. Ltd. Brochure, 1952, 87 pp. Shell-Mex House, Strand, London, W. C. 2.

A booklet intended primarily for engineers and others concerned with the practical prevention of corrosion. Part I

consists of an excellent brief elementary survey of the mechanism of electrochemical attack. Part II gives an account of petroleum-base temporary protective coatings and of their selection applications and removal, with some notes on the Shell "Ensis" protectives.—BNF. 5980

1.6.5.8.2

Soluble Silicates. Their Properties and Uses. Vol. 2. *Technology.* JAMES G. VAIL. Book, 1952, 669 pp. Reinhold Publishing Corp., New York.

Describes film-forming properties of silicates and their use in all manner of industrial materials and techniques including adhesives, laminates, sizing, fire protection, cements, plastics, etc. Use of soluble silicates in form of gels and their properties as catalysts, protective agents and stabilising materials are covered in detail. Emphasis is placed upon principles and properties, rather than upon their degree of industrial significance.—BTR. 5981

1.6.5.9.1, 5.3.4

Chemical and Electroplated Finishes—The Protective Treatment of Metals. Ed. 2. H. SILMAN. Book, 1952, 479 pp. Chapman and Hall, Ltd., 37 Essex St., London.

Modern industrial finishing processes, together with chemical and physical principles involved. This edition contains some revision together with substantial additions. The opening chapter gives a brief account of principles of corrosion. Remainder of the book deals with industrial processes, giving a brief scientific explanation, the processes proper, plant requirements, process control and testing. New material on blasting, descaling, polishing methods and compositions, emulsion cleaning, chemical finishes and coloring, plating machines, electrodeposition, testing methods etc.—MR. 5882

1.7 Organized Studies of Corrosion

1.7.1

Corrosion Committee Adds Gulf Coast and Southwest Test Sites. *ASTM Bull.*, No. 190, 34-35, 1953, May

Cooperative efforts of 148 companies have resulted in ASTM Advisory Committee on Corrosion exceeding its \$100,000 goal set in 1949. Expenses of the program to date have totalled \$30,000, indicating an average expenditure of less than \$8000 per year, and on this basis the \$103,650 received should last longer than the original 10-year period. The new test sites have been set up in the Canal Zone, Kure Beach, N. C.; Point Reyes, California; New York, N. Y.; East Chicago, Ind.; Columbus, Ohio and State College, Pa. Committee B-7 on Light Metals and Alloys has exposed more than 1500 aluminum and magnesium specimens in the form of sheet, plate and tension specimens at N. Y., Kure Beach and State College and further plans call for a similar number of specimens at Point Reyes and Freeport.—ALL. 6231

1.7.1.1.8

Corrosion and Marine Fouling. B. CALLAME AND H. RABATE. *Peintures, pigments, vernis*, 29, No. 2, 115-21 (1953).

An account is given of the life of



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1.7.1, 2.2.2, 6.4.1

Atmospheric Exposure of Light Metals. L. H. ADAM. *Am. Soc. Testing Materials*, Preprint No. 13s, 1953, 24 pp.

An account of the beginning of some tests covering 27 aluminum alloys and 8 magnesium alloys, wrought and cast, to supplement the earlier work of the society. Specimens include some riveted and welded. One industrial, one rural and three sea-coast sites. Effect of exposure will be assessed by mechanical tests. Not all the specimens have yet been placed on location but ultimately data collected will be reported to ASTM Committee B-7 and published. A number of photographs are shown of specimens after six months' or one year's exposure.—BNF. 6281

1.7.3

New Corrosion Testing Service. *Chem. Eng.*, 60, No. 6, 138-139 (1953) June.

Kenneth Tator Associates, Coraopolis, Pa., announces the establishment of a custom corrosion testing service for industrial environments. Selected industrial exposures, under rigorous control, are made available to manufacturers of industrial coatings and other corrosion mitigating methods for objective testing of their products.—INCO. 6244

2. TESTING

2.1 General

2.1.1

Graphical Multiple Correlation of Corrosion Data. O. B. ELLIS. *Corrosion*, 9, No. 6, 203-208 (1953) June.

The evaluation of corrosion data by statistical methods often is desirable in order to obtain maximum useful information from the data. This discussion is concerned with a graphical method for a multiple correlation analysis involving several variables. The graphical procedure is easier to use than mathematical procedures. Also, it provides visual evidence of the relationship between variables as the work progresses. The method is not limited to simple linear functions.

For the purpose of illustration, weight loss data from an atmospheric exposure of low alloy steels are studied. The method is described step by step and the effect of concentration of nickel, manganese, phosphorus and silicon on weight loss is shown. The final results of the graphical analysis are compared with a mathematical analysis of the same data. 6104

2.2 On Location Tests

2.2.1, 8.4.3

These Tools Ferret Out Corrosion. K. W. ROBBINS AND W. M. KELLY. Otis Pressure Controls, Inc. *Oil Gas J.*, 51, No. 16, 114+ (1952) Aug. 25.

Most common practices for determining the presence of corrosion are coupon tests, surface and subsurface water samples, carbon dioxide, visual inspection and internal caliper surveys. The best method is any given well at

any particular time is the use of the internal caliper. The instrument is described and the charts representing the condition of the tubing are interpreted. In an effort to insure maximum life of subsurface equipment 18-8 stainless, R Monel, K. Monel and 416 heat-treated stainless are being used.—INCO. 5878

2.2.2

Outdoor Exposure Testing on Racks and Test Fences. K. G. COMPTON. Bell Telephone Lab. Paper before ASTM, Symp. on Conditioning and Weathering, 55th Ann. Mtg., N. Y., June 24, 1952. Am. Soc. Testing Materials, Special Technical Publication No. 133, 87-90, 1953.

Influence and interrelation of location, angle and direction of exposure, the boldness with which the specimens are exposed and the season of the year at which the test started are discussed. Difference in corrosion rates of open hearth steel specimens exposed close to the ocean and at a short distance from it is given in a table. The various test locations are listed. 12 references.—INCO. 6288

2.2.2, 5.4.5

Comparative Exposure Tests on Typical Exterior Paint Formulations Containing White Zinc Pigments. R. W. BAILEY AND A. PASS. *J. Oil Colour Chemists Assoc.*, 36, No. 394, 171-191 (1953) April.

An account of exposure tests, lasting three years, on exterior paints pigmented with zinc oxide and lithopone, made at six sites likely to represent the full range of climatic differences to be found in the United Kingdom. Data were obtained on the durability of typical mixed pigment formulations incorporating zinc pigments and used in exterior paints; on the effect of various types of zinc oxide on durability and on the effects of locality and climatic variations. All the paints containing zinc pigments had useful lives of at least three and a half years and a pigment mixture of 60% zinc and 40% rutile titanium dioxide was found to be outstandingly better than any of the other pigmentations.—ZDA 6266

2.2.5, 5.3.2, 5.4.5, 8.1.2

Durability of Paints on Weathered Galvanized Roofing. M. L. BURGENER AND D. G. CARTER. University of Illinois Agricultural Experiment Station. March, 1953, 16 pp.

Some four hundred galvanized sheets, forming the roofs of six farm buildings, were given either one or two coats of a large number of different paints. The initial condition of the sheets in 1932 varied from new to 90% rusted. Critical observations were made of the paint coatings at intervals until 1948. Probably the best performance was given by a single coat of a 4/1 zinc dust/zinc oxide paint, a second coat applied after a few years being more satisfactory than an initial double coat. It is difficult to draw definite conclusions owing to the limited nature of the data.—ZDA 6258

2.3 Laboratory Methods and Tests

2.3.1, 4.4.1

Corrosion Testing; A Tool of Conservation. E. G. HOLMBERG. *Chem. Eng. Progress* (Engineering Section), 48, 377-380 (1952) Aug.

Discusses value of corrosion testing.

Describes methods and apparatus used and presents data obtained for several stainless steels, nonferrous alloys and special high-temperature alloys in solutions of various common organic chemicals at temperatures of 223 and 270°F. Includes photographs and diagrams.—BTR. 5988

2.3.2, 1.6

Symposium on Conditioning and Weathering. ASTM Special Technical Publication No. 133, 1953, 98 pages, 6 x 9 inches, paper cover. American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

Consisting of 10 papers presented at the ASTM 50th Anniversary Meeting, New York, June 24, 1952. Of special significance to corrosion workers are: Fundamentals of Atmospheric Elements, B. C. Haynes; Conditioning and Weathering of Adhesives and Plastics, F. W. Reinhart; Weathering of Some Organic Coatings, E. J. Dunn, Jr.; Weathering Tests on Metallic Coatings, William Blum; Development of a Moisture Resistance Test, C. P. Lascaro; Outdoor Exposure Testing on Racks and Test Fences, K. G. Compton; Accelerated Weathering Devices, R. H. Sawyer. 6095

2.3.2, 2.4.2, 4.2.3, 3.4.8

The Corrosion of Gas-Burning Appliances. J. WELSH. *Chemistry and Industry*, No. 25, 551-555 (1952).

General corrosion mechanisms and effects in gas-fired appliances are discussed and illustrated. Accelerated tests on copper water-heaters protected by lead-tin confirmed that corrosive attack decreases with decrease in the amount of organic sulfur compounds present, though with gases of high sulfur content a protective layer of lead-sulfate is formed. An apparatus consisting of a horizontal rotating wheel by means of which thermally regulated specimens can be continuously passed into and out of flue gases of controlled composition, under conditions similar to those in gas-fired water heaters, is described and results obtained with nickel, zinc, copper aluminum and lead specimens are presented. In the case of copper coated with hot-dipped lead-tin alloys the weight of corrosion products increased with increasing tin content and copper was always present in the deposits, although the coating seemed intact, which is in agreement with copper migration by means of a copper-tin compound. The possibility of placing a barrier layer between the copper and the coating is being investigated. The actual corrosion rate of alloy steels tested was smaller than that of coated metal specimens.—MA. 5955

2.3.4

Surface Areas of Metals and Metal Compounds: A Rapid Method of Determination. C. ORR ET AL. *J. Metals*, 4, No. 6, 657-660 (Section 1), (1952) June.

The method described depends on measuring the amount of stearic acid adsorbed by the powder from a solution in pure, dry methanol after shaking for about half an hour. The stearic acid concentration after adsorption is determined by conductometric titration with sodium hydroxide. Comparison is made with results obtained by other methods and good agreement found with the nitrogen adsorption method. A result is quoted for zinc dust, but zinc oxide was observed to

April, 1954

react chemically; this was thought to be due to insufficient drying.—ZDA. 5975

23.4, 3.3.4, 4.5.1

Corrosion of Iron and Steel by Aqueous Suspensions of Sulphur. T. W. FARRER AND P. WORMWELL. *Chemistry & Industry*, No. 5, 106-107 (1953) Jan. 31.

Discusses the elementary sulfur found in the products of the anaerobic microbiological corrosion of iron and steel. Suspensions of sulfur in distilled water were prepared by dispersing washed precipitated sulfur in 5% suspension of bentonite in water. Specimens of cast iron and steel were immersed in the suspension. Corrosion was rapid. The rapid attack of iron or steel by sulfur might be an important factor in the corrosion of buried metals under conditions in which sulfate-reduction can occur together with subsequent oxidation of the sulfide produced. 7 references.—INCO. 6116

23.4, 6.2.1, 1.6

Ferrous Analysis, Modern Practice and Theory. E. C. FIGOTT. Second revised edition, 1953, 670 pages. John Wiley & Sons, Inc., 440 Fourth Ave., New York, New York.

The book gives in detail procedures for analyzing ferrous compounds and lists the various techniques used in analysis. Chapters deal with available analytic techniques and their proper choice. The constituents of iron and steel are arranged alphabetically; there are other chapters on the microchemical analysis of iron and steel, alloys and ores and refractory materials.

Each principal constituent of iron and steel is discussed separately. The proper method and technique for analysis of each constituent is given in detail and an extensive bibliography is given listing books which deal more extensively with specific techniques for analysis.

Tables list the classification and several characteristics of Main Quantitative Techniques, of Special Quantitative Techniques and of Special Semi-Quantitative Techniques. 6154

23.5, 3.6.1, 3.8.2

Electrochemical Behavior of Metals as a Basis for the Study of Corrosion. R. PIONTELLI. *Corrosion*, 9, No. 4, 115-122 (1953) April.

Some general concepts in the study of the electrochemical behavior of metals are introduced.

The experimental arrangements for the determination of polarization diagrams are discussed on the basis of the results obtained working on model cells.

An entirely new type of arrangement is described.

Some typical experimental results are given and some general rules are deduced concerning the electrochemical behavior of metals.

A brief mention is given of the possible relations between this behavior and structural properties of metals and solutions and the passivity problem. 6152

23.5, 3.6.8, 5.2.4

Measurement of the Corrosion Rate of a Metal from Its Polarizing Characteristics. W. J. SCHWEDTFEGER AND O. N. McDORMAN. *Natl Bureau of Standards J. Electrochem. Soc.*, 99, No. 10, 407-413 (1952) Oct.

Theoretical electrical relations between the polarizing characteristics of the elements of a galvanic couple and the polarizing characteristics of the couple

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itself are described. Expression for the measurement of corrosion rate, which has been confirmed only for the special case of single couples, applies to the corrosion of steel in soils and presumably in other aqueous media. From the relation between the potential of a corroding metal and the applied external current, the type of control of the corrosion rate was deduced. Significance of the slope of polarization curves with respect to corrosion rate is indicated. Graphs and references.—INCO. 5973

2.3.5, 6.3.21, 3.2.3, 3.4.7

Oxide Film Formation on the Surface of Metallic Mercury in Aqueous Solutions and the Anomaly Between Its Potential and That of the Mercury-Mercuric Oxide Electrode. S. E. S. EL WAKKAD AND T. M. SALEH. *J. Phys. Chem.*, 56, No. 5, 621-625 (1952) May.

The reason for the previously reported anomaly between the potential of the mercury electrode in aerated solutions and that of the mercury-mercuric oxide electrode is clarified by studying: a) the anodic behavior of mercury utilizing both the cathode ray oscillographic method and the direct potentiometric method. b) The effect of bubbling oxygen through the solution on the potential of the electrode as well as the pH value of the solution. It is shown that the discrepancy is mainly due to the increase of the pH of the solution by the increased amount of mercuric oxide which must go into solution in order to satisfy the Hg_2^{++}/Hg^{++} equilibrium and the probable consequent formation of a basic salt. Diagrams and graphs are included. 10 references.—INCO. 5974

2.3.9, 1.3

Radioactive Tracers in Physical Metallurgy Research. M. B. BEVER. Pamphlet, 1953, pp. 278-311. Reprint from a book "Modern Research Techniques in Physical Metallurgy," published by American Society for Metals.

A survey based on 157 references. Elementary nuclear physics and radiochemistry; manipulation of tracers and design of experiments; detection of tracers by counting or by autoradiography; application of tracer techniques to structural investigations; diffusion measurements; metal surface phenomena, etc.—BNF. 6238

2.3.9, 2.3.6

Corrosion Resistance of Metals Studied with Interferometer. *Chem. Eng. News*, 31, No. 21, 2096, 2100 (1953) May 25.

R. G. Pike and Donald Hubbard of National Bureau of Standard's Mineral Products Laboratories have devised an interferometer procedure which detects corrosion to a depth of 0.003 microns on optically flat specimens. It can be used for checking the accuracy of block gauges, etc. A ground and polished sample is immersed to one half its depth in a corrosive solution, withdrawn, rinsed and dried, and covered with an optically flat piece of quartz. Interference fringes will then be seen in a conventional interferometric viewing apparatus of the Pulfrich type illuminated with an unfiltered helium lamp, as vertical parallel, continuous lines. If corrosion has taken place, lateral shifting of the vertical fringes will be noted at the level of solution line.—ALL 6251

2.3.9, 3.5.9

The Metallographic Investigation of Failed High-Temperature Components. J. C. WRIGHT. Mond. Awarded the Students' Essay Prize of the Inst. Metals for 1952. *Bull. Inst. Metals* (London), 1, Pt. 13, 112-115 (1952) Sept.

Metallographic preparation, mechanical breakdown, formation of unsatisfactory microstructures during service and dry-corrosion failures are discussed. No satisfactory classifications of failures are possible since the mechanism of breakdown is usually complex. 17 references.—INCO. 6105

2.3.9, 5.5.3, 5.9.4

Radiometric Determination of the Efficiency of Water Displacement From Phosphated Surfaces. STANLEY L. EISLER. *Org. Finishing*, 13, No. 6, 19-21 (1952) June

Gives experimental procedure for the above. Presents results of experiments on 10 different water-displacing, rust-preventive compounds on steel panels. Shows that one of the compounds which was very good when tested on sand-blasted panels proved inferior when tested with phosphated panels. This demonstrates that it is not possible to extend results from one test condition to the other. It is recommended that all compounds be tested for their efficiency in displacing water from phosphated surfaces if it is planned to use them on such surfaces.—BTR. 5986

2.4 Instrumentation

2.4.2, 2.3.4, 8.4.3, 5.8.4

A Laboratory Method for Screening Oil Well Corrosion Inhibitors. J. A.

CALDWELL AND M. L. LYTLE. *Corrosion*, 9, No. 5, 186-187 (1953) May.

Because a field test of an inhibitor may require six months or more, it is obvious there is need for a dependable laboratory procedure for screening the many substances available. This paper describes a weight-loss test in which accurately weighed mild steel coupons are exposed to corrosive fluids from wells producing sour crude oil. Three sketches of laboratory apparatus are shown. Correlation between laboratory and field test results has been good. 6126

2.4.2, 4.4.7, 7.1

How to Evaluate Lube Oil Additives. M. A. HUGHES AND E. C. HUGHES. *Standard Oil Co. Petroleum Processing*, 7, No. 9, 1274-1279 (1952) Sept.

Laboratory motor oil oxidation test, developed to obtain significant information on performance in a severe engine operation such as the L-4 test, was used to advantage in evaluating some 47 oil additives and oil inhibitors which are said to protect against deterioration in such service. The procedure, known as the Polyveriform lube oil oxidation test, is given and the apparatus described. Graphs and tables.—INCO. 5937

2.4.3

Ultrasonic Equipment for High-Precision Thickness Measurement. PETER K. BLOCH. *Non-Destructive Testing*, 11, 21-23 (1953) May.

Deals with refinements in equipment and technique which have made it possible to obtain thickness measurements within $\frac{1}{2}\%$ of actual dimensions with ultrasonic resonance instruments.—BTR. 6222

2.4.3

Non-Destructive Testing Reveals Casting Defects. J. M. ANSPACH. *Mechanite Metal Corp. Am. Machinist*, 97, No. 5, 117-124 (1953) Mar. 2.

Development of 4 non-destructive testing procedures applicable to castings includes radiography or penetrating radiation, magnetic-particle inspection, penetrant methods and ultrasonic testing. Each of the testing methods has a specific field of use. The steps to be followed in the selection of a non-destructive inspection are given.—INCO. 6234

2.4.3, 7.2

Ultrasonic Testing Used for Small-Diameter Tubing. A. J. PARDUS. *General Electric Co. Iron Age*, 171, No. 5, 110-113 (1953) Jan. 29.

High-frequency pulsating sound waves sent into the tubing locate flaws by reflecting from the defect. Any discontinuity reflects the sound waves back to a searching unit which presents them on a reflectoscope. With thin-wall tubing, a shear wave is generated by an angle quartz crystal and sent angularly into the tubing. Best results are obtained with a 1-megacycle, 1-in. quartz crystal, angle searching unit. Photographs.—INCO. 6156

2.4.3, 8.9.1

Quality Control Applications of Non-Destructive Tests in the Airframe Industries Which Will Effectively Lower Production Costs. B. W. CLAWSON. *Non-Destructive Testing*, 11, 25-27 (1953) January.

Deals with non-destructive testing as it is currently being utilized and expanded within a specific airframe manufacturing installation.—BTR. 6268

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2.6 Preparation and Cleaning of Specimens

2.6, 2.4.2, 5.9.2

A Metal Cleaning Test Using Radioactive Stearic Acid as Soil. Parts I and II. J. W. HENSLEY, H. A. SKINNER, AND H. R. SUTER. *Metal Finishing*, 50, 49-52, 77-80+ (1952) July, Aug.

I. Procedures are given for producing a uniform, reproducible abraded surface on steel test pieces, and for applying very thin, uniform, and highly reproducible films of tagged stearic acid to the surface of metal test discs. Descriptions are given of special apparatus used in preparation and coating of metal test pieces. Cleaning-test data are given showing removal from steel of stearic acid soil by single-component alkali solutions, with variation in cleaning time and solution concentration, and by one organic detergent solution, with variation in cleaning time. II. Describes test apparatus and procedure. Cleaning test results for removal of stearic acid films from steel, using different agents, are charted and tabulated.—BTR. 5983

3. CHARACTERISTIC CORROSION PHENOMENA

3.1 General

3.1, 2.3.7, 3.5.8, 3.5.7

The Influence of Corrosion on the Cracking of Pressure Vessels. H. R. COPSON. *Welding J.* (N. Y.), 32, 75S-91S (1953) Feb.

This report is a comprehensive review

of corrosion with particular emphasis on stress corrosion and corrosion fatigue. The forms of corrosion briefly discussed are: uniform attack, local attack, galvanic attack, corrosion cracking, corrosion-erosion, and subsurface attack at high temperatures. Ways of detecting and preventing caustic embrittlement are described. Stress-corrosion cracking is discussed for the following: iron, stainless steel, copper alloys, aluminum alloys and magnesium alloys. Methods are given for the testing for and prevention of stress-corrosion cracking. The general aspects of corrosion fatigue and methods of identification and protection are discussed. Corrosion fatigue data of several metals and alloys are given. Finally, the effect of stress on general corrosion and the effects of hydrogen generated by corrosion are discussed. 101 references.—NSA. 6287

3.2 Forms

3.2.2, 3.4.8

Mechanism of the Action of Ionized Solutions of Hydrogen Sulfide on Iron and Steel. PAUL BASTIEN AND PIERRE AMIOT. *Compt. rend.*, 235, 1031 (1952).

Embrittlement is caused by hydrogen ions in the solution which migrate into the metal lattice and separate at defects and dislocations. The iron sulfide formed is secondary as far as the effect is concerned. Hydrogen sulfide in non-ionizable media (benzene) does not cause embrittlement, and the embrittlement (and fatigue) is obtained by gaseous hydrogen sulfide if water vapor is present and condensing. 5958

3.2.2, 3.6.2

Filiform Corrosion. M. VAN LOO, D. D. LAIDERMAN, AND R. R. BRUHN. *Corrosion*, 9, No. 8, 277-283 (1953) August.

Filiform corrosion is a thread-like type of corrosion which develops under protective coatings on certain metals, usually in humid atmospheres. It is characterized by directional growth and definite structure. Controlling factors are the physical nature of the coating and the exposure conditions. Normally each growing thread consists of an active head of an unstable corrosion product and an inactive body of a stable corrosion product. Filiform corrosion usually appears in an apparently haphazard or disorderly pattern. However, its growth is uniform and orderly in direction, rate and dimensions when developed under controlled conditions. The tracks do not cross one another but deflect or join in a predictable manner. To date no direct relationship has been found between filiform corrosion and the metallurgical pattern of the surface, the presence or absence of light, biological activity or the presence of inhibitive pigments. It has been observed under both non-metallic and metallic coatings, provided that the coatings are semi-permeable and are sufficiently elastic to yield without rupture to the volume of the oxide formed. A theoretical explanation is offered for filiform corrosion, involving an initiating force, a driving force and a directing force. It is suggested that corrosion anodes are initiated by an electrolytic mechanism as in ordinary corrosion. The driving force is the diffusion of the corrosive atmosphere into the active head, resulting in further metallic corrosion. The directing force is explained on the basis of concentration cells. 6169

3.2.2, 6.2.5, 4.3.6

Protection of Stainless Steel From Pitting in Salt-Containing Environments. L. CAVALLARO AND C. BIGHI. *Metallurgia Italiana*, 44, No. 819, 361-365 (1952). *Electroplating & Metal Spraying*, 6, No. 1, 29 (1953) Jan.

Study was made on the conditions of protection from pitting of 18/8 austenitic steels in salt-containing solutions by addition of small quantities of caustic soda. Tests were made with inhibited solutions at various concentrations and in active solutions of the same salt content but differently aerated. Tests were extended to 18 ferritic chromium steels. The inhibiting effect of caustic soda was also extended to this type but to a lesser degree. Results show that in place of the addition of molybdenum in order to avoid pitting under these conditions, caustic soda in small concentrations may be used.—INCO. 6098

3.2.2, 6.4.2, 8.4.5

Pitting of Aluminum in a Heavy-Water Reactor. *Nucleonics*, 10, 19 (1952) July.

The fuel rods in the heavy-water reactor at Kjeller, Norway, consist of uranium slugs stacked inside aluminum tubes with 2-mm. walls. Pitting and corrosion have affected the outer surface of these tubes where they were immersed in the heavy-water moderator. 4 photographs.—MR. 5987

3.2.2, 8.4.3, 2.3.4, 6.2.3

Hydrogen Blistering of Steel in Hydrogen Sulfide Solutions. T. SKEL, A. WACHTER, W. A. BONNER, AND H. D. BURNHAM. *Corrosion*, 9, No. 5, 163-172 (1953) May.

Extensive damage to some refinery equipment has occurred owing to transmission through steel of the hydrogen formed during corrosion of steel by hydrogen sulfide solutions. Damage in the form of hydrogen blistering, fissuring and embrittlement of steel has been particularly severe in catalytic cracking gas plants. Laboratory investigations have been made of the relative influence of environmental factors on the rate and extent of hydrogen transmission through carbon steel. These studies include determination of the effects of concentration of important constituents such as hydrogen sulfide, low molecular weight organic acids, ammonia and hydrogen cyanide. Several other compounds were studied and found to be of minor importance. The laboratory method involved measurement of the volume of hydrogen which passed through to the opposite side of a thin wall of carbon steel. In certain hydrogen sulfide environments hydrogen transmission practically ceased after a short time. This behavior is ascribed to formation of a protective scale of iron sulfide. However, in certain alkaline solutions containing cyanide ion, corrosion and a high continuing rate of hydrogen transmission occurred owing to formation of a ferro-cyanide complex which prevented development of a protective scale. On the basis of the data obtained it is shown that rate of hydrogen transmission can be reduced greatly by indicated changes in chemical environment. 6168

3.2.3

The Nature of the Film Present on Iron After Brightening in Marshall's Solution. A. HICKLING, W. A. MARSHALL,

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and E. B. BUCKLE. Paper before Inst. Metal Finishing (incorporating Electrodepositors' Tech. Soc.), London, Feb. 18, 1952. *J. Electrodepositors' Tech. Soc.*; 28; 47-60; disc. 61-68 (1952).

Presence of a film upon iron after treatment in the Marshall smoothing solution was demonstrated. The formation of the film after withdrawal of the specimen from the solution is independent of the oxalate ion. Evidence indicated that the film consisted of a thin but tenacious and continuous layer of oxide. By reducing the film cathodically in an ammonium chloride electrolyte and observing the quantity of electricity involved, the thickness of the film was estimated and found to be of the order of 60 Å, assuming the film to be anhydrous ferric oxide. Graphs and 8 references.—INCO. 5985

3.2.3, 3.5.8, 2.3.5

Film Rupture Mechanism of Stress Corrosion. *Technical News Bulletin, National Bureau of Standards*, 36, No. 4, 54-55 (1952) April.

In a study of stress corrosion of aluminum and other metal alloys, new data are given on the mechanical and electrochemical phenomena involved. Electrochemical potentials were measured first for unstressed specimens having normal thin oxide films. Potentials were then measured for the same specimens after the filmed surfaces had been removed by abrasion with metallographic polishing paper. Each metal studied was more cathodic in the normal film-coated form than in the abraded form. The electrochemical solution potentials were measured in the normal condition with stress applied. When tension is initially applied to a metal, small breaks develop in the protective film, giving corrosion chance to get started before a fresh film can form. In an endeavor to measure the change of potential with stress applied, on a film-free surface, a calomel electrode was placed in an electrolyte in which the test specimen was immersed. The potential readings obtained represented essentially the potential of the relatively large film-covered surface. In reality, the film-free surface is so small that it is not possible to detect any change of potential when the specimen is stressed. By coating an entire notched specimen with a non-conductive waterproof lacquer, then using a razor blade to remove a narrow band of lacquer at the root of the notch, the only potential measured is that of the narrow band of metal at the root of the notch where the stress is concentrated. With a fairly rapid application of stress the film-free area then becomes a substantial fraction of the total non-lacquer-covered area, and the potential becomes more negative as the stress is increased. In the 24S-T4 aluminum alloy, in an electrolyte of KCl (saturated), the electrochemical solution potential on an unstressed specimen with normal film was 0.67 volts. In the film-free condition it was 1.43 volts, the maximum change being 0.610 volts. 5920

3.2.3, 3.5.9

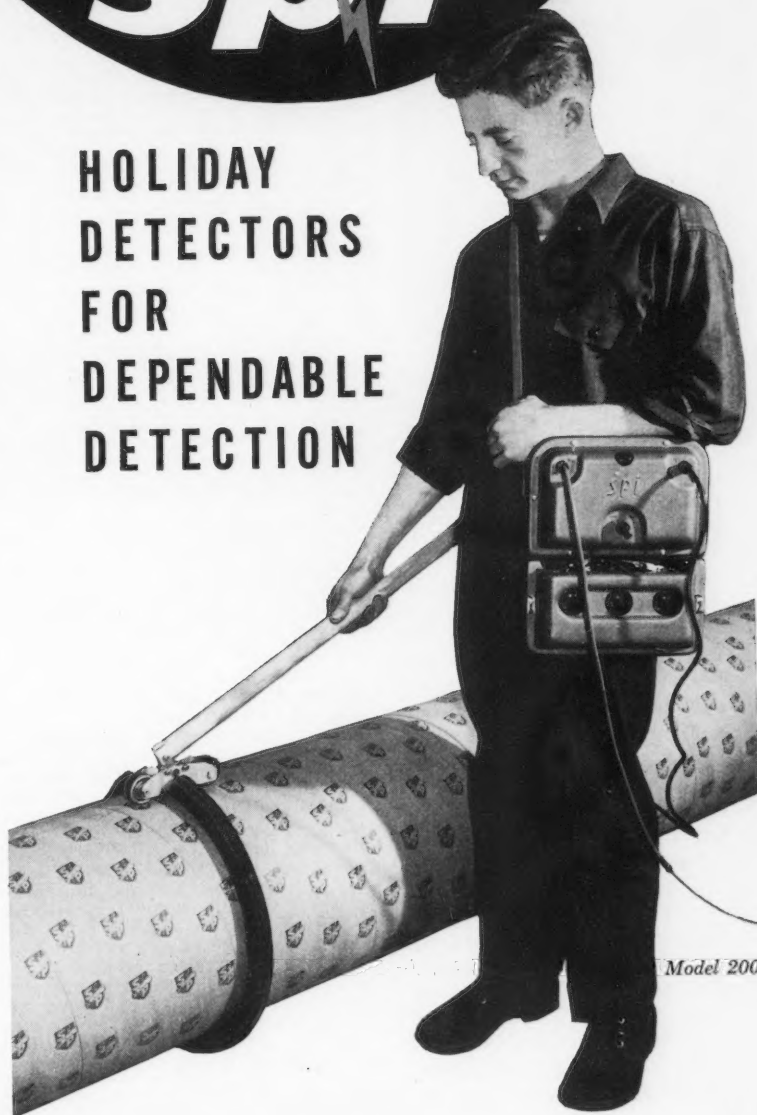
The Effect of Phase Boundary Reaction in the Oxidation of Metals and Alloys at Higher Temperatures. (In German). K. HAUFFE and H. PFEIFFER. *Z. Electrochem.*, 56, 390-398 (1952).

Shows, on the basis of experimental results on oxidation of iron to ferrous oxide at 1000° C., and on the sulfuriza-

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tion of nickel to nickel monosulfide at 670° C., that in these cases, the parabolic time law and the Wagner scaling theory are not applicable, since boundary surface reactions are rate dependent. It is further shown that the presence of metal oxide vapors (molybdenum trioxide and lithium oxide in the oxidizing atmosphere increase the rate of oxidation of metals and alloys, or may decrease it, which is interpreted on the basis of the theory of the formation of defects. Tables and graphs.—BTR. 5961

3.2.3, 3.8.3

Sorption of Gases on Metal Powders and Subsequent Change in Metal Reactivity at Room Temperature. H. L. WANG and N. HACKERMAN. Univ. of Texas. Study supported by ONR under contract N5ori-136 T.O. II. *J. Phys. Chem.*, 56, No. 6, 771-774 (1952) June.

The sorption of oxygen, carbon monoxide, nitrogen peroxide, and chlorine on stainless steel, molybdenum and nickel powders. Only carbon monoxide was truly adsorbed on stainless steel and nickel powders forming a chemisorbed monolayer. All other gases appeared to have first adsorbed, then diffused inward, and finally reacted with the metal. The subsequent effect of sorption of oxygen and carbon monoxide on the reactivity of stainless steel, nickel and chromium powders in terms of relative rate of hydrogen evolution in dilute acid solutions in an air-free system at room temperature is described. Tables, graphs, and 8 references are included.—INCO. 5951

3.2.3, 3.8.4

Theoretical Analysis of the Diffusion Processes Determining the Oxidation Rate of Alloys. CARL WAGNER. *J. Electrochem. Soc.*, 99, No. 10, 369-380 (1952).

A theoretical analysis is made for specified ideal conditions of the interplay of diffusion processes in metallic and oxide phases during the oxidation of alloys. The oxidation rate of alloys containing a noble metal (gold or platinum) and an oxidizable metal (nickel, copper, or zinc) is calculated as a function of the alloy composition. It is shown that the oxidation rate of nickel-platinum alloys at 850° and 1100°C. is essentially determined by the diffusion of nickel to the alloy/nickel oxide interface if the mole fraction of nickel is less than 0.5. Oxidation rates observed are in accordance with values calculated from diffusion data. If both constituents are oxidizable, the alloy may form a one-phase or a two-phase scale. A necessary condition for the formation of a scale consisting of one oxide only is stated, and it is shown that the results for copper-nickel and copper-zinc alloys are essentially in accordance with theory. It is illustrated by observations on the copper-aluminum system that two oxides can nucleate initially and continue to grow even under conditions under which exclusive formation of oxide of the less noble metal is a possible process. 47 references.—MA. 6201

3.2.3, 3.8.4

Influence of Furnace Atmosphere on Surface Finish of Round Ingots and Tubes. (In German). WERNER SCHEURER. *Stahl und Eisen*, 72, 935-941 (1952) July 31.

Laws governing the scaling process. Dependence on temperature, thickness

of scale layer, time, rate of gas flow, type of gas, and its composition. Operation with oxidizing and reducing flames. Effect of an atmosphere rich in sulfur. Effect of protective gases. Experimental results tabulated, charted, and illustrated. 39 references.—BTR. 5869

3.2.3, 3.8.4, 6.3.21

Scaling Characteristics Make or Break a High Temperature Metal. D. D. BICCIOTTI. North American Aviation, Inc. *Iron Age*, 171, No. 21, 144-146 (1953) May 21.

The oxide formed on the surface of a metal during oxidation determines to a large extent the type of reaction that will occur. Tight, adherent oxides are self-protective. Volatile, porous oxides are nonprotective. Linear, parabolic and logarithmic oxidation curves show that parabolic oxidation produces protective coatings. Some of the metals that oxidize parabolically are iron, copper, manganese, zirconium, titanium, nickel, and beryllium in order of decreasing oxidation rate. Silicon dioxide forms a glass which is the best type of protective coating. A study of the oxidation of germanium is briefly discussed. Graphs, 9 references.—INCO. 6272

3.2.3, 6.3.6

Study on the Selective Oxidation of Copper-Aluminum Alloys by Diffraction. D. WATANABE, S. OGAWA AND T. KIMURA. *J. Japan Inst. Metals*, 17, No. 3, 108-113 (1953) Mar.

The surface products due to the selective oxidation of copper-aluminum alloys (1-10% aluminum) heat-treated at 500-800° for 15 minutes in hydrogen stream saturated with water vapor were examined by the electron diffraction method. In case of specimens which showed a high resistance to the discoloration, the patterns obtained did not agree with that of $\gamma\text{-Al}_2\text{O}_3$, but were similar to that obtained previously by Harrington et al. The subsequent gas-heating of these surfaces caused the films to change into $\gamma\text{-Al}_2\text{O}_3$, which had, however, a lattice symmetry slightly different from that of the ordinary spinel type. The refraction effect of electrons due to minute crystals of cupric oxide produced on the alloy surface was also observed.—JSPS. 6127

3.2.3, 7.1, 6.3.4, 6.3.10, 2.4.2

The High-Temperature Oxidation of Some Cobalt-Base and Nickel Base Alloys. A. PREECE AND G. LUCAS. *J. Inst. Metals*, 81, Pt. 4, 219-227 (1952) Dec.

A description is given of the oxidation characteristics of cobalt and nickel and of a number of alloys based on these metals, in the temperature range 800°-1200°C. A simple apparatus was designed to supply an atmosphere similar in composition to that produced in gas turbines, paraffin containing 2% sulfur being used as fuel. Reactions occurring within the scales are compared with those that take place when mixtures of oxides are heated at similar temperatures. Of the reactions noted, spinel formation is shown to be detrimental to the formation of a protective oxide layer. The effects of a number of minor alloying elements, viz. vanadium, boron, niobium, beryllium, titanium, zirconium, calcium, tantalum, aluminum, cerium, silicon and thorium, on the oxidation of a cobalt-32% chromium alloy are described. Several elements increased the



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resistance to oxidation, in particular thorium and silicon; vanadium and boron, however, were highly deleterious, owing to the formation of low-melting point oxides. The rate of oxidation of cobalt shows a sharp decrease in the region of 950°C. and this coincides with the upper limit of stability of Co_2O_3 . It appears that the presence of this oxide at the outer surface of the scale increases the rate of oxygen transfer to the underlying CoO . From a consideration of scale structure and the occurrence of internal oxidation in a number of the alloys, it is suggested that oxygen diffusion through the scale occurs to a considerable extent.—MA. 5861

3.3 Biological Effects

3.3.4, 2.2.7, 2.2.6, 7.2, 5.2.1

Bacterial Corrosion of Offshore Structures. J. A. CALDWELL AND M. L. LYTLE. *Corrosion*, 9, No. 6, 192-196 (1953) June.

Reports published by the British Admiralty and by individuals in England and the United States, show that sulfate-reducing bacteria can cause corrosion of iron under some conditions. Because of the importance of maintaining in good condition the steel pilings of offshore structures in the Gulf of Mexico, a research investigation of the possibility of bacterial corrosion of these installations was inaugurated. Laboratory tests were directed toward developing fairly pure cultures of sulfate-reducing bacteria and using them in both natural muds and synthetic culture media for the purpose of determining their effect on the corrosion rate of steel coupons under anaerobic conditions. Maximum corrosion rates obtained were of the order of 0.001 inch per year. Several assemblies of twenty coupons each were installed at a marine platform approximately seven miles off Grand Isle, Louisiana; the coupons on each assembly were spaced to extend a few feet above and a few feet below the mud line. Somewhat similar assemblies were installed immediately offshore at Barbour's Cut, near La Porte, Texas, and at the Crash-Boat Basin at Galveston, Texas. Results of the study show that the corrosion rate due to bacterial action is low, and that cathodic protection is a sufficient safeguard against bacterial corrosion. 6293

3.3.4, 4.6.13, 4.5.1, 6.6.5, 8.9.3

The Bacterial Sulphur Cycle. K. R. BUTLIN. *Research*, 6, No. 5, 184-191 (1953) May.

In view of the large scale use of sulfur in industry, combined with its recurring shortage, investigations on the potentialities of the microbiological production of sulfur compounds are important. Raw materials essential to this process are sulfates, reducing agents and nutrients for growth of the bacteria. Concrete sewers, and buried iron pipes distributing water, gas and oil have been rendered useless by bacterial action. Corrosion of the sewers takes place in the space above the liquid level where the material is exposed to hydrogen sulfide formed partly by proteolytic bacteria but mostly by sulfate reducers from inorganic sulfates in sewage. 18 references.—INCO. 6253

3.4 Chemical Effects

3.4.8, 3.3.4, 6.2.2, 4.5.1

The Influence of Ferrous Iron on Bacterial Corrosion. MARY E. ADAMS AND T. W. FARRER. *Brit. Dept. of Scientific and Industrial Research. J. Applied Chem.*, 3, Pt. 3, 117-120 (1953) March.

Ferrous ions markedly increased the corrosion rate of cast iron by sulfate-reducing bacteria (*Desulphovibrio desulphuricans*) under heterotrophic and autotrophic conditions. After 300 days in Baars' medium, cast iron discs, $\frac{3}{4}$ by $\frac{1}{8}$ in., lost about 35 mg. by corrosion. The addition of 0.5% ferrous ions as ferrous ammonium sulfate to the medium increased corrosion to a loss of 110 mg. in 300 days. In the presence of yeast extract, the corresponding corrosion losses in the absence and presence of ferrous ions were about 15 mg. and over 400 mg., respectively. In autotrophic Baars' medium (containing sodium bicarbonate instead of sodium lactate), corrosion losses were increased from about 25 mg. to 85 mg. by the addition of ferrous ions.

The corrosion product in the media containing no ferrous ion was hard, crystalline, and very adherent, especially in Baars' medium containing yeast extract. In the presence of ferrous ions, however, the corrosion product was loose, porous, and flocculent. These facts indicate the pronounced effect of the ferrous ion content of soils on the corrosion rate of buried metal structures such as pipe lines. In some clay soils, ferrous sulfide is formed as a hard adherent crust on the pipe, whereas in others the corrosion deposit is several inches from the pipe and the corrosion rate is rapid.—PDA. 6291

3.4.10, 6.2.3

Studies in the Corrosion of Metals Occasioned by Aqueous Solutions of Some Surface-Active Agents. Part II. Mild Steel. T. K. ROSS AND H. HOLNESS. *J. Applied Chem.* (London), 2, Pt. 9, 520-526 (1952) Sept.

Action of dilute aqueous solutions of anionic, cationic and non-ionic wetting agents on mild steel sheet was studied. London tap-water, distilled water and Permutit-softened tap water were used. The effects of varying the pH of the water used, and of temperature changes, were investigated. Results using the various surface-active agents are expressed graphically. The normal rusting attack experienced by mild steel exposed to plain water may be considerably modified by the presence of surface-active agents. 7 references.—INCO. 5890

3.5 Physical and Mechanical Effects

3.5.8, 2.3.7

Fretting Corrosion. K. H. R. WRIGHT. Paper before Brit. Soc. Rheology, Symp. on "Abrasion and Wear of Materials," London, Jan. 4, 1952. *Nature*, 169, No. 4298, 450 (1952) Mar. 15.

Series of experiments in which environmental and mechanical conditions such as humidity and surface adsorption of oxygen were controlled. Oxide initially formed in the fretting corrosion of steel was Fe_2O_3 , but ultimately $\alpha = \text{Fe}_3\text{O}_4$.

was found. Lubricated, phosphated steel surfaces were very resistant to fretting corrosion, but nickel-plating, contrary to belief, was ineffective as inhibitor.—INCO. 6090

3.5.8, 2.3.7, 1.6

Fatigue of Metals. R. CAZAUD. Book (Translation from Third French Edition), 1953, 334 pp. Chapman & Hall Ltd., London.

This is a somewhat extended translation of the 1948 third edition of Cazaud's book, including some new material supplied by the author and reference to some researches recently completed at the N.P.L. The various sections cover characteristics of fatigue failures; theories of the mechanism; fatigue testing and machines; fatigue limits of metals and alloys (ferrous alloys, copper, aluminum, magnesium, lead and alloys); effect of various factors (type of stress application, size and shape of parts, surface condition, temperature corrosion and chemical action), fatigue of structural joints, improving fatigue strength of components.—BNF. 6274

5. PREVENTIVE MEASURES

5.3 Metallic Coatings

5.3.4, 1.6

Chromium-Plating: Technique and Applications. (In French). P. MORRISSEY. Book. Published by Editions Marval, 31 Villa d'Alésia, Paris, 1952, 477 pp.

Most aspects of chromium plating are dealt with in this book with the emphasis on engineering rather than decorative applications. Intention is to provide a summary in a practical form of the published information about chromium plating, suitable for industry. There is, however, no critical comment. The book is divided into four parts: 1. Theory of electrolysis (52 pages). 2. Technique of chromium plating (114 pages). 3. Characteristic properties (166 pages). 4. Industrial applications (95 pages). Bibliography of 243 references up to 1951.—BNF. 5634

5.3.4

Second International Conference on Hot-Dip Galvanizing. Paper before the Second International Conf., Symposium on Hot-Dip Galvanizing, Dusseldorf, July, 1952. *Sheet Metal Inds.*, 29, No. 304, 677-706 (1952) Aug.

Papers include: The Ductility of Hot-Dip Galvanized Coatings, H. Bablik, J. Krystof, F. Gotzl, and R. Kukaczka; The Flaking of Hot-Dipped Zinc Coatings, M. L. Hughes; The Potential Behavior of the Iron-Zinc Alloy Layer of Galvanized Steel in Various Hot Aqueous Solutions, R. C. Weast; The Effect of Aluminum and Iron on the Structure of Galvanized Coatings, M. A. Haughton; A Galvanizer's View on Bath Heating and Operation, E. McL. Wilson; Top Heated Galvanizing Bath at Wirsbo, Sweden, N. Thoren; Observations on the Attack of Molten Zinc on Iron, R. Haarmann; Flux Techniques and Hot Galvanizing Economics, A. T. Baldwin; The Galvanizing of Cast Iron, W. Montgomery; The Economics of Galvanizing, F. C. Braby; Working Conditions in Job Galvanizing Plants, H. T. Eatwell; Some Notes on the Recovery of Zinc from Galvanizers' Ash, N. B. Rutherford; The Treatment of Pickle Liquors, A. R. L. Chivers; Trends in Hot-Dip Galvanizing, R. W. Bailey. Discussions on all papers are included.—INCO. 5759

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5.4 Non-Metallic Coatings and Paints

5.4.2, 8.10.2

Coating for Steel Pipe Used in Aluminum Fluxing. *Steel*, 131, No. 1, 98, 100 (1952) July 7.

Barrows Porcelain Enamel Co., Cincinnati, at the request of the Listerhill, Ala. plant of Reynolds Metals Company, has developed a porcelain enamel coating for black steel pipe used in a chlorine fluxing operation for aluminum alloys. The enameling process increases average pipe life 12 to 20 times. Average chlorination tube life was 8 to 10 minutes. To achieve the best enamel within cost limitations, various refractory materials were added to high corrosion resistant coatings. Regular high temperature resistant enamels, such as those used in jet engine parts, could not withstand corrosion by the molten aluminum. Pipes used for the chlorination are about 14 feet long with a 45-degree bend about 24 inches from the exhaust end. The problem of obtaining a perfect coating inside the pipe was solved by closing one end of the pipe, and allowing the molten enamel to fill the erect pipe completely and then run off slowly. The coated pipe has an average life of 148 minutes, and although the cost is about five times as much as plain pipe, the over-all saving is considered satisfactory by the Reynolds Company.—ALL. 5768

5.4.2, 6.2.3, 3.5.9

Coatings for the Protection of Low Carbon Steel at Elevated Temperatures. J. H. HANDWERK AND T. N. MCVAY. Alabama Univ. 1952. 33 pp.

Coatings for the protection of sheet iron from oxidation at elevated temperatures were compounded. These coatings were made by adding a refractory material to the mill batch of a ground-coat enamel. Chromium oxide and aluminum hydroxide were used and it was found that coatings containing chromium oxide did not withstand high temperatures as well as coatings containing aluminum hydroxide. Coatings containing aluminum hydroxide were tested and found to be satisfactory for protecting sheet iron at temperatures up to 1400 de-

grees F for a period of 100 hours. These coatings were also found to withstand a flame impingement test in which a temperature of 1620 to 1650 degrees F was maintained for two hours.—NSA. 5502

5.4.2

Highlights—Nonmetallic Materials. *Product Eng.*, 23, No. 12, 5 (1952) Dec.

Acid resistance and ability to withstand thermal shock describes CRC-14, a porcelain enamel coating for steel. Characteristics of the new finish when applied to low-carbon steel compare favorably with those of stainless steel. Developed by Seapocel Metals Inc.—INCO. 5660

5.4.2

More about Ceramic Coatings. *Product Eng.*, 23, No. 10, 134-141 (1952) Oct.

Ceramic coatings for aircraft heat exchangers, high-temperature alloys, ceramals, molybdenum and resistance wire strain gauges. Includes those developed by U. S. National Bureau of Standards, Stewart-Warner Corp., Solar Aircraft Co. etc. Properties, resistance to corrosive gases (containing lead bromide, sulfur or carbon), methods of application, composition, effect of loading, oxidation tests, U. S. specifications.—BNF. 5659

5.4.2, 5.4.7, 3.5.9

Ceramics Shield Stainless for Jets. R. G. HICKS. Stewart-Warner Corp. *Am. Machinist*, 96, No. 15, 99-100 (1952) July 21.

A-19, A-417, A-418 and A-520 are ceramic coatings which were studied to establish techniques of applying heat-resisting films. Metal preparation and coating process are discussed. Nat. Bureau of Standards ceramic coatings' approximate melted composition, giving nickel oxide content, and characteristics and applications of A-19, A-418, and A-520 are tabulated. A-19, a cobalt-nickel composition, can be applied to cold-rolled, low alloy, Types 302 and 304 stainless steels, Inconel and Multimet N155. NBS #331 does not adhere well to Types 302 and 304 stainless steels, but can be used to coat parts of Types 310, 321 and

347 stainless, all high-nickel alloys, Inconel and Multimet N155. It's unsuitable for low-carbon steels. A-417 can extend the life of Inconel parts as much as 100%.—INCO. 5550

5.4.2, 3.5.9

Refractory Ceramic Protective Coating. F. V. LONG. *SAE Journal*, 60, 38-41 (1952) Sept.

Technically, the Solaramic coating is a thin, vitreous or semi-mat ceramic coating bonded tightly to the metal's surface. This seals the metal against destructive effects of hot gases and combustion products. The smooth coating surface offers little friction to gas flow. This, combined with prevention of surface oxidation, closes the door on hot spots and thus protects the parent metal against cracking and warping in high temperature operating conditions. Its extreme flexibility and bonding strength makes the Solaramic coating a good protection for sheets as thin as 0.001-inch. The coating can cover all type welds and various alloys in different thicknesses that may be used in making a single part. Standard components can be coated with little or no design changes. The Solaramic coating is also fairly resistant to impact. A sharp blow may fracture the coating at the impact area; but a thin protective coating will remain. In most cases these spots will heal themselves during operation by coalescing of coating from the surrounding region. This will protect the affected area about as well as the original coat.—TIME. 5527

5.4.2

A Designer's Guide to Vitreous Coatings. T. L. STEDFELD. *Machine Design*, 24, No. 12, 165-172 (1952) Dec.

For service as protective coatings, porcelain enamels are available in a multitude of formulations. General types which may be used are: Sheetmetal enamels, cast iron enamels, ceramic coatings (better known heat-resistant coatings are the A-417, A-418 and Ryanco A-418C, and the Solaramic coatings) and glass linings. Uses of these enamels are covered.—INCO. 5765

5.4.5, 5.3.2

One-Day Conference on Nickel Chrome Alternatives. H. A. NEWNHAM. *Ind. Finishing (Brit.)*, 4, No. 43, 458, 461, 485 (1952).

The use of colorless lacquers as plating reinforcements on chromium plate has been made necessary since nickel is in short supply. In this case, the lacquer is the only barrier against corrosion. It functions as a physical barrier and must therefore be hard and tough and able to withstand water, water vapor, fruit juice, oil, etc. The preparation of the film is of great importance; the surface must be clean and the lacquer must be neither under- nor over-stoved as this causes discoloration. Cellulose lacquers and styrenated alkyds are used.—RPI. 5714

5.4.3, 8.9.3

New Pipe Coating Process. FRANK H. LOVE. *Petro. Engr.*, 24, D7-D8 (1952) June.

The impact application of H. C. Price Co.'s Hevicote, a heavy concrete-type coating, to line pipe to give it negative buoyancy and protection from corrosion.—MR. 5584

5.4.3

Experience with Gunite Linings. *Oil Gas J.*, 51, No. 8, 115 (1952) June 30.

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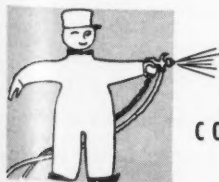
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5.4.3, 7.2

New Twist in Glass Lined Pipe. S. C. ORR. *Pfaudler Co. Can. Chem. Proc.* 36, No. 6, 48 (1952) June 1.

Glassalloy joints permit the use of alloy pipe couplings while preserving the inherent corrosion resistance of glass lined flanged pipe. Two short alloy rings of Hastelloy C, Inconel, Type 347, or low-carbon grades of Types 304 and 316 are welded to the ends of a length of low-carbon steel tubing. The glass lining is applied through the length of pipe by conventional means but it terminates at either end on the alloy ring. Currently under investigation as a material for cast fittings are the new ductile cast irons.—INCO. 5719

5.4.5, 4.6.11

Vinyl Coatings Protect Marine Installations from the Ravages of Corrosion. H. E. WALDRIP. *Gulf Oil Corp. Oil Gas J.*, 51, No. 6, 291-292 + (1952) June 16.

Definition, composition, testing, specifications, application and performance of vinyl coatings for marine installations and surface preparation for coating steel surfaces are discussed. Pointers for the inspection of vinyl coatings and recommendations for improving vinyl performance are given. Photographs and tables of salt-fog-cabinet and fresh-water-bath tests and field inspection of coated barges are included. 11 references.—INCO. 5801

5.4.5

Epoxide Resin Coatings Have Excellent Chemical Resistance, Adhesion and Abrasion Resistance. T. R. HOPPER. *Shell Chem. Corp. Materials and Methods*, 36, No. 3, 90-93 (1952) Sept.

New surface coating materials, a group of epoxide resins, known as Epon, have been developed. The resins, which are especially useful in the protective coatings industry, are Epon 1001, 1004, 1007 and 1009. Physical and chemical properties, resistance to chemicals and solvents and the fields of applications are discussed.—INCO. 5511

5.4.5

Corrosion-Resistant Coatings. *Heating, Piping, Air Cond.*, 24, No. 10, 206, 208 (1952) Oct.

Ricwilit phenolic resin coatings are designed to protect equipment against extremely corrosive conditions with a tough film which resists corrosive acids, alkalis, salt water, rust and weather. One type hardens to form a chemically inert coating when baked at 350-400 degrees F. Another, of the cold-setting type, is cured at room temperatures by the addition of a catalyst just prior to application. It can be applied to metals, concrete, wood and plaster surfaces by brush or spray. Manufactured by Ric-Wil Plastic Coating & Manufacturing Corporation.—INCO. 5510

5.4.5, 5.3.2

Clear Protective Coatings for Copper-Chromium Plate. WAYNE R. FULLER. *Plating*, 39, No. 6, 616-618, 622 (1952).

Experiments are described for determining which of a number of clear lacquers was the most suitable for applying over copper-chromium plate to enhance its protective effect. The work was necessitated by the need to omit the normal intermediate nickel plate, this omission greatly reducing the corrosion-resistance of the plate. It is concluded that a mixed alkydamino-formaldehyde lacquer is the most promising type for this purpose. Information is included on the preparation of the article to be lacquered and on methods of stripping defective coatings. Brief information is also given on the use of clear coatings on zinc-base alloys.—MA. 5492

5.4.5, 5.4.2

Zinc Dust as a Protective Pigment. A. PASS. *J. Oil Colour Chemists Assoc.*, 35, No. 384, 241-261 (1952) June.

Methods of preparation and the physical, chemical and pigmentary properties of zinc dust are described. A review is made of various paint formulations in which the pigment is used, including the cementiferous paints based on inorganic binders. The theoretical considerations underlying the anti-corrosive properties of zinc dust paints are discussed and attention drawn to the different considerations which seem to apply to marine and atmospheric exposures. Tests show that paints formulated on zinc dust give excellent corrosion resistance to steel against both atmospheric and sea water attack. It is concluded that the chief obstacle to the extensive use of such coatings for marine purposes is the tendency to blister and although electro-endomosis may be largely responsible, highly metallic zinc coatings develop alkaline surfaces on contact with sodium chloride solutions which may produce intercoat blisters if saponifiable following coats are used.—ZDA. 5686

5.4.5

Phenolic Resin Coatings for Corrosion Resistance. *Paper Trade J.*, 135, No. 12, 214 (1952) Sept. 19.

Ricwilit coatings are special formulations to protect equipment against corrosive conditions in all types of industry. The tough impervious film is resistant to attack by acids and alkalis, salt water, rust and weathering. Ricwilit 1060 is of the baking or heat-hardening type, while Ricwilit 7100 is a cold-setting type. The coatings are applied to almost all metals, concrete, wood and plaster surfaces. Mfd. by Ric-Wil Plastic Coatings and Mfg. Corp.—INCO. 5679

5.4.5, 7.7, 4.2.4

Stainless Steel Paint. *Paper Trade J.*, 135, No. 12, 169 (1952) Sept. 19.

Stainless steel pigmented paint, particularly good for industrial atmospheres, was applied to distribution transformers installed opposite a steel plant. The finish looked perfect after 1½ years exposure. Formulated of flakes of stainless steel mixed with suitable vehicle, it proved a desirable paint for certain electrical equipment. Developed by Westinghouse Electric Corporation.—INCO. 5678

5.4.5, 5.4.6

Pennsalt Gives Key to Savings in Painting Costs. ROBERT R. PIERCE. *Chemical Eng.*, 59, 149-153 (1952) May.

On basis of comprehensive evaluation

of general-purpose systems in chemical-industrial atmospheres, a 3-coat system that will give enough build per coat for a 5-mil minimum total thickness is recommended. 62 paint materials were studied. Data are tabulated and charted. Some results are illustrated.—BTR. 5669

5.4.5, 5.9.4, 5.8.2

Recent Developments in Surface Protection. *Motorship*, 36, 24 (1951); *J. Brit. Shipbuilding Res. Assoc.*, 7, No. 2, 138 (1952).

A number of examples of surface coatings and surface treating techniques are listed. Corrosion inhibition by volatile amine nitrates and by phosphatizing compounds is described. Proprietary protective coatings such as anti-rust paints, plastic and coal-tar coatings and metallic lacquer finishes are listed.—RPI. 5617

5.4.5

Work of the Protective Coatings Commission of the Assoc. Belge Pour l'Etude, l'Essai et l'Emploi des Matériaux. P. EACULISSE. *Chem. & Ind.*, No. 16, 353 (1952).

A summary of the work carried out by the commission. The results of a 10-year exposure program showed the superiority of red lead/linseed oil over most other primers and that the durability of paints on low-alloy steel was considerably better than on ordinary steel. Tests on underwater coatings and new priming formulations are in progress.—RPI. 5605

5.4.5

Mica for Surface Coating. *Ind. Finishing (Brit.)*, 5, No. 51, 130-132, 134-135 (1952).

Powdered mica can partially replace the pigment in corrosion-resisting paints. It forms a layer impervious to oxygen, water and salt solutions. It often retards settling and aids redispersion of settled pigments.—RPI. 5630

5.4.5, 8.9.2

Modern Automobile Polishes. M. A. LESSER. *Soap Sanit. Chemicals*, 28, No. 6, 144-147, 173, 175 (1952) June.

Developments in automobile polishes. A novel addition, an aliphatic amine, in a cleaner-polish serves to prevent corrosion of polish-containing cans. Another auto polish, stable and non-creaming, made with a dimethyl polysiloxane fluid, not only provides a good polish, but also forms a coating that protects the car from corrosion due to salt spray. This is particularly useful in coastal areas. 26 references.—INCO. 5598

5.4.5

Highlights—Nonmetallic Materials. *Product Eng.*, 23, No. 12, 5 (1952) Dec.

A modified phenolic resin, Phenoline 300, is a corrosion resistant coating which will bond to nearly any surface and has a temperature range of -70 to 400°F. It can be used as a lining, paint or seal for porous castings and for repairing leaks in welded and riveted tanks. Manufactured by Carbolite Co.—INCO. 5665

5.4.5

Liquid Stainless Steel. Lockrey Frater Corp. *Prod. Fin.*, 5, No. 1, 85 (1952).

A quick-drying liquid in which are suspended microscopically fine particles of stainless steel, the vehicle used being a vinyl plastic solution, has now been used on several major jobs with success. This paint gives a durable protective coating of stainless steel which resists

acids, moisture and abrasion and combines toughness with flexibility. It is also unaffected after subjection to salt spray (200 hr.) and (sodium) hydroxide spotting (24 hr.). The material can be sprayed, brushed or dipped.—RPI. 5662

5.4.5 Vinyl Resin Solutions and Dispersion Coatings. G. M. POWELL AND J. F. SUTER. *Paint and Varnish Production*, 43, No. 7, 14-20, 47-48 (1952).

The following aspects were discussed: Types of vinyl chloride/acetate copolymer; effect of diluents on the viscosity of solutions of the copolymer; modifications of the copolymer with free COOH or OH groups; uses of vinyl resin solution coatings; wash primers; anti-corrosive and anti-fouling coatings based on the copolymer; vinyl resin dispersion coatings—latices, organosols and plastisols; electron-micrograph studies of the fusion process in the application of vinyl resin dispersions; diluent/dispersant balance in organosols; plasticizer and packing requirements in plastisols; use of organosols and plastisols for cloth coating, manufacture of unsupported films, floor coverings, etc.—RPI. 5653

5.4.5 Source, Production and Application of Dehydrated Castor Oil in the Protective Coatings Industry. T. C. PATTON. *Official Digest Federation Paint and Varnish Production Clubs*, No. 326, 177-202 (1952).

The world production of castor seed and the properties of dehydrated castor oil are discussed. Varnishes prepared from the oil sometimes exhibit after-tack. To test for after-tack a 90-lb. Kraft paper is pressed on to the surface of the film with a force of 2 lb. per sq. in. for 5 sec.; the panel is then inverted and if the paper is released within 10 sec., after-tack is considered absent. After-tack may be reduced by replacement of a proportion of the oil with tung oil; reducing the oil length, using pure phenolic resins with unbodied oils and modified phenolic resins with bodied oils and using bisphenol or pentaerythritol/maleic anhydride resins. Correct utilization of the oil in aluminum paints is described. In a comparison of the oil with linseed oil in white house paints it was found that the former had better pigment wetting properties and gave more rapid drying paints, application properties and can stability being similar for the two oils. The use of the oil in house paints, architectural enamels, gloss and flat wall paint, calcicoaters (flat wall paints based on a limed vehicle) flat and gloss emulsion paints, traffic paints, primers for marine atmospheres and zinc chromate primers for aluminum and magnesium is described, with representative formulae for each type. Satisfactory varnishes for baked can coatings can be prepared from the oil with maleic resins; a 15-gallon oil length is desirable where the metal is to be fabricated after coating, but otherwise a 10-gallon oil length may be used.—RPI. 5647

5.4.5 Anti-Rust Paints Can be Applied Directly on Rust Surfaces. *Materials and Methods*, 36, No. 2, 146, 148 (1952) Aug. New line of chromate anti-rust paints called Overust, announced by Chem. Industrial Co., are applied directly over rusted surfaces without wire brushing or sandblasting. One coat is sufficient to prime, penetrate and seal all metal surfaces.—INCO. 5577



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5.4.5, 6.4.2

Wash Primer Helps Industry Fight Corrosion. R. A. GARLING, *Iron Age*, 170, No. 4, 102-107 (1952) July 24.

Wash primers permit application of house paints to aluminum metal surfaces and recently aluminum chairs have been sprayed with a Vinylite resin-base wash primer in place of anodizing. Wash primer is a vinyl resin prime coat developed in World War II to keep ships free from rust and fouling for longer periods. It combines the most desirable properties of a phosphate metal preparation and zinc chromate primer. It inhibits corrosion and spread of corrosion at the metal-coating interface. It wets the metal surface and has excellent adherence when dry. It provides a suitable surface for bonding subsequent coats. It is applied by conventional painting methods, with special formulations for dipping and gives good coverage and dries quickly. Wash primer is advantageously bonded to a standard vinyl topcoat through a vinyl intercoat in which mica and aluminum pigments are added to decrease film permeability. Formulae for two typical wash primers are as follows:

BASE GRIND	WP-1 Parts by Weight	XE-5220 Parts by Weight
Vinylite resin XYHL.....	7.2	9.0
Zink tetroxy chromate or basic zink chromate pigment *	6.9	....
Lead Chromate (low in soluble salts) **.....	....	8.6
Talc (asbestine 3x).....	1.1	1.4
Isopropanol, 99 per cent.....	50.4	53.0
Toluene.....	14.4	....
Methyl isobutyl ketone.....	....	13.0
	80.0	85.0
Acid Diluent		
Phosphoric acid, 85 per cent.....	3.4	2.9
Water.....	3.4	2.9
Isopropanol, 99 per cent.....	13.2	9.2
	20.0	15.0

* Mineral Pigment Corp. M1828 or Imperial Paper and Colour Co. No. 2259.

** Imperial Paper and Colour Co. A-548.

—ALL. 5564

5.4.5

Silicones in Paints. P. MOREL, *Peintures, pigments, vernis*, 28, No. 5, 310-317 (1952).

The use of silicones in paints is discussed with reference to the following properties: adhesion—the high coefficient of linear expansion ($\times 10^{-6}$) of silicones (150-210) as compared to metals, e.g., steel (13-16) or aluminum (23-26), and other resins, e.g., urea/formaldehyde (25-30), melamine/formaldehyde (20-55) or alkyls (55-60), acts against good adhesion; in addition, a thorough degreasing of the metal surfaces is required (burning or trichlorethylene vapor), otherwise traces of fatty material may be decomposed with the formation of gaseous products at the high stoving temperature of the silicones, which will weaken the adhesion; abrasion resistance and hardness—stoved silicones are harder than many organic resins; a device for increasing abrasion resistance is to incorporate a small proportion of an incompatible silicone oil which will exude to the surface; flexibility—this depends on the nature and proportion of organic radicals in the molecules, and may be reduced by the presence of metals, e.g., drier metals, in the composition; heat resistance—unpigmented silicone compositions will not stand very long exposures to temperatures greater than 325°, but, if certain pigments, e.g., aluminum, are incorporated, resistance to greater than 800 de-

grees can be obtained; corrosion and water-resistance—silicones have no special merits; chemical-resistance—good, but certain materials (acetic or citric acids) can cause a reduction in gloss; solvent resistance—greater, the less the proportion of organic radicals in the silicone molecule; weather resistance—very high, even if the silicone constitutes only 50% of the film-forming material. Precautions necessary in the manufacture and application of silicone paints are outlined.—RPI. 5646

5.4.5

Wash Primer. *Ind. Finishing* (U.S.A.), 29, No. 1, 26, 28, 30 (1952) Nov.

This wash primer was originally developed by the Bakelite Division of Union Carbide and Carbon Corporation as a highly adhesive undercoat for navy vessels for subsequent overcoating with hot plastic bottom paints. This primer still shows excellent performance after five years of actual marine service. Its Navy specification MIL-C-15328A describes it as a primer pretreatment coating. It is used in the petroleum industry for pipe lines, oil storage tanks and drilling platforms. It is used for such metals as stainless steel, aluminum, zinc, cadmium, tin, magnesium alloys and galvanized iron. It is normally green in color and is composed essentially of basic chromate pigment in a polyvinyl butyral vehicle. It is thinned with a solution containing phosphoric acid, this is added slowly with stirring and the mixture must be used within eight hours. The prime coat should be applied to this pre-treatment within 24 hours. It is sufficiently dry for priming within 30 minutes. The pre-treatment may be applied to damp surfaces but not to wet surfaces. The tendency of sprayed wash primer to "string" or "cob-web" can be minimized by the addition of 10 percent butanol.—ALL. 5549

5.4.5

The Protective Action of Paints. J. E. O. MAYNE, *Research*, 5, No. 6, 278-283 (1952) June.

Inhibition of corrosion may be brought about by stopping the cathodic reaction, or the anodic reaction, or by inserting between the anodic and cathodic areas a high electrolytic resistance. Paint films are so permeable to water and oxygen that they cannot inhibit the cathodic reaction, and the anodic reaction can be suppressed only when paints contain certain pigments. Zinc dust paints provide cathodic protection; anodic passivation is provided by the basic pigments, zinc oxide, basic lead oxide, basic lead sulfate and the linoleates of zinc, lead, barium, calcium and strontium; and by the soluble pigments, zinc chromate and zinc tetrahydroxychromate. In general paint films inhibit by virtue of their high electrolytic resistance.—ZDA. 5541

5.4.5

Anti-Corrosion Primer With Vinylite Resin Base. *Machinery* (N. Y.), 58, No. 10, 192 (1952) June.

Vorac H-400, high-adhesion metal wash primer with a Vinylite resin base developed by the Vorac Co., is used under almost all types of coatings. Films are formed by evaporation of solvents. A zinc chromate compound, it provides an adherent base coating on most metals and alloys, is applied by dipping, brushing or spraying, and dries in less than 30 minutes. It is a metal conditioner and should be applied only to clean surfaces.

The compound cannot be applied over a phosphated surface, is always used with one or more top coats and is supplied in two parts for mixing at the time of use.—INCO. 5538

5.4.5

Rust-Inhibitive Primer for Non-Prepared Surfaces. *Machinery* (N. Y.), 58, No. 16, 173 (1952) Aug.

Vinyl primer, Tygorust, was developed for use on rusted steel surfaces without any prior preparation. It is applied by brushing, spraying, or dipping, dries hard and can be overcoated in a matter of minutes. It adheres to rusted steel, damp or dry, and can be used with any type of finish coating—particularly vinyl resins. Developed by U. S. Stoneware Co.—INCO. 5525

5.4.5

Strippable Plastic Finish Provides Corrosion Protection. *Machinery* (N. Y.), 58, No. 10, 192 (1952) June.

VC-12, a strippable plastic finish developed by the United Lacquer Mfg. Corp., is a vinyl finish available in clear and tinted clear colors. It is sprayed or brushed to all metal or wood surfaces, sets to touch in 15 minutes and dries hard overnight. The finish is easily peeled off all non-porous surfaces in sheet-like form. Uses include the temporary masking of objects during manufacturing operations, as in the automobile appliance industries, lining of paint spray booths in factories and protection in metal-etching operations.—INCO. 5519

5.4.5

Metallic Powders and Pastes as Pigments. V. J. HILL, *Paint, Oil Col J.*, 122, No. 2805, 137-141 (1952) July 18.

This paper, read before the Borough Oil and Colour Students' Association, reviews the use of granular and flake metallic powders as pigments. The importance of paints pigmented with metallic zinc lies in their ability to protect underlying steelwork sacrificially even when the paint film is no longer continuous. Paints of this type are available which give films containing about 95% metallic zinc. The protective properties of zinc-rich paints are said to be independent of the shape of the metallic pigment. Very little published information is available on the production of zinc powder pigments.—ZDA. 5514

5.4.5

Metallic Lead Primers. *Paint Technol.*, 17, No. 193, 13 (1952).

The properties of metallic lead primers are described briefly and compared with a red lead primer. The lead primer shows less brush marking and better protection in a salt spray test than red lead.—RPI. 5723

5.4.5, 8.9.5

Marine Paints: A Review of Recent Trends in Ship Coatings. *Paint Manuf.*, 22, 330-335 (1952) Sept.

Surveys various factors of fouling and corrosion together with development of marine coatings with specific qualities required for varying conditions found on ships. Surface preparation before paint application is emphasized and results of a series of efficiency tests are described, while future trends in marine paint field are discussed.—BTR. 5726

April, 1954

5.4.5, 5.3.2

Clear Lacquers for Plated Parts. *Metal Finishing*, 50, 57-59, 101 (1952) May.

Protection from corrosion or decay. Properties of paints and lacquers for silver, brass and copper with emphasis on chromium plate.—MR. 5590

5.4.5, 5.4.2, 4.6.11

Marine Applications of Zinc-Rich Paints. *Shipbuilding and Shipping Record*, 79, 402 (1952) Mar. 27; *J. Brit. Shipbuilding Res. Assoc.*, 7, No. 5, 293-294 (1952).

The article outlines the nature of polystyrene and chlorinated rubber based zinc-rich paints and of cementiferous paints. The electrochemical action of these paints is briefly described. Examples of the effective use of zinc-rich paints are given. The bottom of a Dutch yacht was painted with a zinc-rich paint followed by one coat of anti-fouling before it went into service; after 12 months the zinc coating was still intact. Swedish trials on patching damaged galvanizing with the same paint are said to have been very satisfactory.—ZDA. 5757

5.4.5

Fundamentals of Aluminium Paint. E. SCHELLER. *Am. Paint J.*, 36, No. 22, 82+ (1952) Feb. 18.

In a general discussion of the characteristics of aluminum powder as used with various mediums to form aluminum paint, the nature of the pigment and grading of the powder is discussed first. Aluminum paints have very high leafing characteristics, without which the painted surfaces would appear dark and grey. Leafing qualities are measured under Federal Specification TT-A-468A, by which specification a leafing power of 50 percent is required. It is in the treatment of aluminum paste or powder that its stability is fixed. The brightness of the paint film is in proportion to the leafed surface. The risk of gas generation in a can of paint which has been stored for a period is considerable and suitable precautions must be taken to prevent the accumulation of moisture. Since aluminum paint reflects light, deterioration of the surface is very slow. The ability of aluminum to withstand attack by moisture will increase the life of any surface painted with it. Aluminum paints function in a heat insulation capacity, because the paint does not dissipate the heat so readily by radiation.—ALL. 5760

5.4.6, 2.3.7, 2.3.9

New Standard for Coating Thickness. M. KRONSTEIN. New York University. *Chem. Eng.*, 59, No. 6, 201-203 (1952) June.

After measuring the profile of grit-blasted steel surfaces and determining the effect of various thicknesses of organic coatings on moisture penetration, it was concluded that coating thicknesses should be three times the profile depth to resist moisture penetration. Study of the profile using a Brush Dev. Co. Model BL-103 surface analyzer, evaluation of a completed coating system using a Magne-Gage to determine film thickness of finished coatings, and testing by electrographic printing for moisture penetration and under-film spreading of moisture are discussed. Required minimum film-thickness for a given steel surface can be quickly determined by electrographic printing. Illustrations. 2 references.—INCO. 5623

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5.4.7

Chlorinated Rubber Paints. *Trav. Peinture*, 7, No. 10, 313 (1952).

In brush-application of chlorinated rubber paints, the brush should be well loaded and the paint must not be too much worked over. It is unwise to apply the paints over a fresh oil paint film. In spray application, a low pressure and wide nozzle should be used. Chlorinated rubber paints are recommended for iron rather than wood, except where a priming coat based on an alkyd resin is first applied.—RPI. 5781

5.4.7, 8.9.3, 5.4.5

Durability of Hot-Sprayed Bituminous Rust-Preventing Paints. B. STECHER. *Hansa*, 89, 779 (1952); *J. Brit. Shipbuilding Res. Assoc.*, 7, No. 7, 429 (1952).

In a previous article (See NACE Abstract Card No. 846, Classified 5.4.7), the author recommended the use of hot sprayed bituminous paints for protecting iron and steel against rust. In this article, he quotes the case of a steel pipe-line which was protected in this way in 1934, and which has recently been inspected and found to be in perfect condition. The contractors who performed this work employ three different spraying techniques. In the first, the bitumen is placed at some 400 degrees F in a 33-gallon tank and sprayed by an oxygen-free gas under pressure. The second method is similar, but the container has a maximum capacity of ten gallons and is therefore more readily portable; the temperature is maintained by heating the container, the piping, and the spray gun electrically. In the third method, a small container holding 1 lb. of bitumen is an integral part of the spray gun; the bitumen is melted by electric heating and sprayed on with heated compressed air.—RPI. 5762

5.6 Packaging

5.6.1, 5.8.2

The Prevention of Corrosion in Packaging. Part I. The Use of Sodium Benzoate as a Corrosion Inhibitor in Wrappings. E. G. STROUD AND W. H. J. VERNON. *J. Applied Chem. (London)*, 2, No. 4, 166-172 (1952) April.

Sodium benzoates and other soluble benzoates can be used for the production of corrosion-inhibitive wraps by impregnation in materials such as paper, strawboard, regenerated cellulose films and waxed papers. Provided the chloride content of the wrap is sufficiently low before impregnation, complete protection is effected for steel under adverse conditions of storage and transport. The corrosion of common non-ferrous metals is in no case increased; in particular, the attack on zinc (quite small for the plain cellulose film, rather heavier for the unimpregnated board) is substantially reduced in the presence of the inhibitor and attack upon solder and soldered joints is suppressed. The waxed wrap is noteworthy for a marked increase in the attack upon magnesium and upon zinc.—ZDA. 5770

5.6.1, 5.8.2

The Prevention of Corrosion in Packaging. Part II. Temporary Protectives from Rubber Latex and Other Aqueous Dispersions. E. G. STROUD AND W. H. J. VERNON. *J. Applied Chem. (London)*, 2, No. 4, 173-177 (1952) April.

Metal articles can be given a strip-

pable protective coating by dipping in cold concentrated rubber latex (preferably vulcanized) in which a corrosion-inhibitor, compatible with the latex, is incorporated. Sodium benzoate is effective for this purpose for steel and certain other metals under adverse conditions of storage or transport. The sodium salts of certain other carboxylic acids may also be used. The best all round protection (effective for cast iron, solder, tinplate and non-ferrous metals except cadmium and magnesium) is afforded by 5% sodium benzoate and 0.4% sodium nitrite, each calculated on the dry rubber content of the latex. Protective films which are hard and generally non-strippable may also be obtainable by the addition of benzoate to emulsions of other organic high polymers such as polyvinyl acetate, polyvinyl chloride and copolymers.—ZDA. 5755

5.6.1, 5.8.2

The Prevention of Corrosion in Packaging. Part III. Vapour-Phase Inhibitors. E. G. STROUD AND W. H. J. VERNON. *J. Applied Chem. (London)*, 2, No. 4, 178-183 (1952) April.

Of many compounds examined in vapor form in moisture-laden air, a number will, in varying degrees, confer protection upon ferrous and some non-ferrous metals when contained in the same enclosed space. Certain esters (e.g. n- and iso-propyl benzoates, n-butyl benzoates and methyl cinnamate) afford good protection to steel. Complete inhibition of the corrosion of steel and cast iron may be effected in moist air even when heavily contaminated with sulfur dioxide, by certain amine carbonates. These compounds also possess, in marked degree, the property of arresting the further corrosion of iron and steel surfaces that have already become rusted by exposure to moist polluted air. The varied response of the common non-ferrous metals to amine carbonates is noteworthy. Aluminum, zinc, chromium-plated steel, tin plate, solder and soldered joints are protected, but the corrosion of copper, copper-rich alloys and magnesium is substantially increased.—ZDA. 5756

5.6.2, 5.8.2

Latex as a Packaging Material for Machine Parts. *Rubber*, 8, 13, 15 (1952).

A good protective layer: (i) must not oxidize, and must give adequate protection against oxidation; (ii) must be thick enough to give protection against mechanical damage; (iii) must be quickly and easily removable. Initially latex, while satisfying (ii) and (iii), did not satisfy (i), as its water fraction caused oxidation of metals. Subsequently corrosion inhibitors such as sodium benzoate and nitrite were incorporated into the latex. Coating methods are described, including the use of heat-sensitive latex for the dipping process.—RPI. 5750

5.6.3

Polyethylene Coatings. L. E. WHITMORE. *TAPPI*, 35, No. 2, 103A (1952); *Fibre Containers*, 36, No. 12, 154 (1951).

Since 1945, polyethylene resins have found wide acceptance in packaging, either as modifiers for paraffin wax, as unsupported thin films, or as thin films laminated to papers or boards. Polyethylene-modified wax mixtures may be applied using conventional equipment without major alteration. Polyethylene

coatings on board or paper are applied either by a hot melt method or an extrusion lamination method. Lower molecular weights have been used with best results. In certain cases, a third method, involving application from hot solution, is being used. The advantages of polyethylene used in conjunction with wax are: Resistance to grease transfer before and after conversion; good moisture-vapor-transfer resistance; good heat-sealing properties; and good flexibility.—RPI. 5802

5.9 Surface Treatment

5.9.2, 5.9.3

Descaling, Derusting and Degreasing of Ferrous Metal and Alloys Surfaces Before Painting. H. RABATE. *Trav. Peinture*, 7, No. 6, 161-163 (1952).

A critical survey and description is given of the methods used for preparing the surface of ferrous metals and alloys before applying a coating, including rubbing with abrasives, stripping, wire-brushing, sand- and steelshot-blasting, descaling with an oxy-acetylene torch or by weathering with subsequent derusting, pickling with dilute sulfuric acid or hydrochloric acid, degreasing with organic solvents or by alkali treatment and phosphating.—RPI. 5752

5.9.3, 5.9.2

Importance of the Preparation of the Surface: Peening. (In French) ROGER MARPON. *Metallurgie*, 84, 463, 465 (1952) June.

The problems of preparing metallic surface before painting. Mechanical and chemical cleaning. Special attention is paid to peening; advantages over other mechanical methods.—MR. 5583

5.9.3, 8.1.2

Flame-Cleaning Steel Structures. *Commonwealth Engr.*, 39, 225 (1952); *J. Brit. Shipbuilding Res. Assoc.*, 7, No. 4, 243 (1952).

The use of the oxy-acetylene process of flame-cleaning is gaining in popularity and for a number of applications has been adopted as standard practice. Mill scale, which is formed on rolled steel principally by occluded moisture, invariably flakes during weathering and results in the breakdown of the paint covering it. When a high-temperature oxy-acetylene flame is passed over a steel surface at the correct speed, it has the effect of cracking and loosening scale that is not firmly adherent, by means of thermal expansion and contraction. Rust in which moisture is present as physically-absorbed or as chemically-combined water, is removed by dehydration. The surface should be cleaned down after the passage of the flame and the paint applied while it is still warm. The fluidity of the paint is greatly increased when it is applied to a warm surface, so that it spreads smoothly and rapidly, bringing the inhibitors into close contact with the metal surface. The bond between the paint coat and the parent metal is considerably strengthened, the drying rate is accelerated; and, since the paint coating dries from the underside towards the surface, the tendency for moisture to be retained in the coating is reduced. It is not considered necessary to remove all scale from the steel, but only that which will separate under the concentrated action of the flame. Experience has shown that mill scale

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that withstands the action of the high-temperature flame is sufficiently tenacious to remain fixed after the painting. The article concludes with a brief description of the flame-cleaning of a railway bridge.—RPI. 5645

5.9.3, 2.3.2, 5.4.5

Shot-Peening (for Surface Preparation Before Painting). R. MARPON. *Trav. peinture*; 7; Nos. 6, 7; 164-167, 208-211 (1952).

Experimental results are reported for the accelerated weathering of painted steel panels prepared by shot-peening with fine and coarse shot to illustrate the importance of selecting a grain size to give a surface roughness corresponding to that obtained by sand-blasting (absence of deep pits) or alternatively, if this has not been done, of selecting a paint system specifically to suit the rough surface; e.g., a chlorinated rubber paint affords much better protection than an oil-based paint, especially if application is by brush.—RPI. 5572

5.9.4

Hard Chromium Coating for Ferrous Parts. G. A. SAMUEL. *Diffusion Alloys Corp. Product Eng.*, 23, No. 8, 164-166 (1952) Aug.

Plant carbon, alloy steels and cast iron made heat, wear and corrosion resistant by an English process called Chromizing. The process, including the effect of alloying elements is discussed. The adaptability of Chromizing to various components as compared to chromium plating and stainless steels and the relative corrosion resistance of chromized materials to various agents, such as water, atmosphere, acids and alkalis, are tabulated. Graphs.—INCO. 5791

5.9.4, 6.2.5

Complex Stainless Parts Resist Corrosion When Electropolished. G. L. SHRIVER. *Electro Polishing Co. Western Metals*, 10, No. 6, 51-52 (1952) June.

Electropolishing is gaining increasing acceptance among Western metal working plants as a finishing process for

stainless steel parts. During the process all areas of even the most complex part receive an identical polishing action and by the very nature of the action are also deburred. The chemically pure surface resulting from the electrolytic polishing increases corrosion resistance in the 400 series stainless steels under ordinary operating conditions by nearly 450%. In the case of the 300 series the increase in corrosion resistance is even greater. Such special metals as Inconel, Monel and Hastelloy also show similar gains in corrosion resistance.—INCO. 5789

5.9.4, 2.3.7

The Porosity of "Eloxidized" Layers. (In German). OSWALD KUBASCHEWSKI AND ARVID VON KRUSENSTJERN. *Metalloberfläche*, ser. A, 6, A97-A102 (1952) July.

Discusses the protective effect of various oxide coatings, and the formation of macropores and micropores in anodizing of pure aluminum. Various methods for judging the porosity of a layer are indicated. Results are interpreted. Micrographs.—BTR. 5619

5.9.4, 6.4.4

Getting the Most from HAE Coatings (on Magnesium). M. FRAGER AND H. A. EVANGELIDES. *Metal Progress*, 62, No. 3, 81-84 (1952) Sept.

The HAE electrolytic process (Pitman-Dunn Laboratories, Frankford Arsenal, U.S.A.) produces a very hard adherent non-metallic coating, 0.001 to 0.002-inch thick, on magnesium. Present paper indicates when HAE may be used in conjunction with other treatments (sealing, phosphating, zinc chromate paint, etc.), discusses the effect of drilling and riveting, and mentions some mechanical tests on the coating.—BNF. 5604

5.9.4

Pretreatment Etch Primers of the Single Solution Type. E. E. HALLS. *Ind. Finishing*, 5, No. 52, 185-189 (1952)

The two-solution type of etch primer is an established first coating medium in the metal finishing sphere. Developed and introduced into American practice during the war, it proved its value as the basis of simple paint protective schemes on both steel and aluminum. During the past three years or so it has been finding regular use in England, not only in specialized applications but also in more general usage in industrial metal finishing shops. This is the first part of an article describing some results obtained in the examination of an etch primer in which the two solutions are mixed in manufacture and suitably stabilized.—EL. 5625

5.9.4

Pretreatment Primers for Metal Work. E. E. HALLS. *Ind. Chemist*, 28, No. 333, 441-445 (1952) Oct.

Chemical pretreatments, composition of pretreatment (or etch) primer paints, drying. Also results of salt spray and humidity tests on enamelled steel, aluminum and brass specimens with various pretreatments. Other basis metals mentioned.—BNF. 5624

5.9.4, 6.4.4

The Surface Treatment of Magnesium. D. R. HENDRY. *Australasian Engr.*, 45, 72-75 (1952) March 7.

The most nearly chemically inert films

on magnesium are those consisting of magnesium oxide. The most common types of bath depositing a film of this sort are the chromium magnesium oxide and hydroxide. There are numerous modifications of these two—the addition of chlorides to the acid chromate bath to increase film thickness on magnesium-aluminum alloys and modification of the acid content. Two other baths producing this type of film consist of chromic acid-permanganate mixtures and chromic acid-magnesium dichromate mixtures. A table lists the chemical pretreatments for magnesium alloys. Fluoride films on magnesium are not very successful owing to their thinness. Magnesium oxide films can be produced by the immersion of magnesium in boiling caustic solutions which may contain sodium sulfate, sodium silicate, phenol and small amounts of nitrate or cyanide. Organic compounds are used as a sealing medium for porous chromate or fluoride films. The electroplating of magnesium has advanced considerably recently. However, for purposes of corrosion protection, other methods are superior. Magnesium alloys can be painted, but contact must be made between the paint and the metal itself, so considerable pre-treatment is necessary, and the metal must be painted immediately thereafter.—ALL. 5556

5.9.4

Phosphate Coating . . . Cleans and Coats in One Operation. *Machine Design*, 24, No. 6, 185 (1952) June.

Rustclean 12, 15, 151, 152, 153 and 121 in concentrated liquid form for water dilution, remove rust, tarnish and light oil and form a phosphate base for organic finishes on steel, iron, aluminum, zinc and cadmium and removes tarnish on copper and alloys. Special inhibited grades for precision parts remove rust without attack on steel and will prevent hydrogen embrittlement. They contain mild acid with less corrosive action than pickling compounds and have no toxic or fuming vapors. Two types are available, one for sponge or brush application and the other for immersion. They are produced by Octagon Processes Inc.—INCO. 5542

5.9.4

A Fast Phosphating Process. *Machinery Lloyd*, (Overseas Ed.), 24, 103-104 (1952) July 5.

The Walterisation "PHO" process and a new development of it, the "E" process, which enables extension to mass-production work such as the manufacture of vehicles, aircraft and shipping where a strongly corrosion resistant coating is essential.—MR. 5532

5.9.4

Phosphate Coating Compound. *Elec. Mfg.*, 50, No. 3, 154, 156 (1952) Sept.

Detrex 79, a water soluble compound that cleans and phosphate-coats steel and iron parts in one operation. The rust-resisting surface serves as a base for paint finishes.—INCO. 5490

5.9.4, 5.4.5

Phosphating Metallic Surfaces. P. DECERMA. *Peinture e Vernici*, 8, No. 3, 143-149 (1952).

The characteristics of phosphate layers on steel are described and original work on the assessment of the efficacy of phosphating in inhibiting corrosion

under paint films reported. Steel panels and tubes, differently pretreated and phosphated (or not), subsequently coated with a primer and an alkyd-based finishing wax, were submitted to the salt spray test. The tabulated results illustrate the advantages of phosphating, e.g., the onset of rusting occurred in about 12 days on the non-phosphated, and in 26-44 days on the phosphated, substrates. The procedure is particularly efficacious on mechanically polished steel, but less so on pickled steel.—RPL 5489

5.9.4 Surface Treatments of Metals With Peroxygen Compounds. *Precision Metal Molding*, 10, No. 12, 53-56, 76 (1952) Dec.

Role played by peroxygen compounds in treating metal surfaces. Staining and passivating procedures are given as examples of surface treatment to produce an oxide film. Copper cleaning process describes the second type treatment by removal of surface components by oxidation. Etching and stripping procedures belong to the third type of treatment which dissolves or removes metal surfaces. Fourth type of treatment is the use of hydrogen peroxide to control the chemical composition of the process solutions used in phosphating iron and steel. 17 references.—INCO. 5667

5.9.4, 2.3.9 Radiometric Study of Phosphating Problems. STANLEY L. EISLER AND PAUL G. CHAMBERLAIN. *Metal Finishing*, 50, 113-116 (1952) June.

A number of problems pertaining to phosphating of steel were investigated. Results indicated that iron from the solution becomes an integral part of the phosphate coating; residual phosphate is present on work after grit or sand-blasting; and rephosphating after grit or sand-blasting results in a lower process efficiency than after chemical removal of the original coating. Tables.—MR. 5515

5.9.4, 6.2.4 Chromizing Steel Provides Corrosion. Wear Resistance. *Western Metals*, 10, No. 9, 54-56 (1952) Sept.

Superior heat, corrosion and wear resistance is provided on ordinary low-alloy steel by a relatively new chromizing process carried out by the Chromizing Co. of California. Advantages of the process, successful applications, and the chromizing procedure are discussed.—INCO. 5798

5.9.4, 6.4.2, 2.3.7 Surface Treatment and Finishing of Light Metals; Part 7. S. WERNICK AND R. PINNER. *Sheet Metal Inds.*, 29, No. 307, 1027-1036, 1040 (1952) Nov.

The series continues with a discussion of physical and chemical properties of anodic coatings, especially coating thickness. Determination of film thickness is accomplished by a number of methods including direct microscopic measurement and break-down voltage and by destructive methods including dissolving the coating and dissolution of the metal. Coating porosity is discussed and a method for its determination is outlined. The adhesion of the coating is normally much better than that of electrodeposits but the film tends to be weak vertical to the surface. When bent the coating cracks in parallel lines but will not strip as electrodeposits do. In general adhesion of the film increases with

increasing temperature, acidity and the use of direct current, as well as low current densities and longer treatment time. Hardness, abrasion resistance and flexibility of anodic coatings on eight aluminum alloys are compared and the methods of obtaining results are outlined. The corrosion resistance of anodic coatings is discussed and tables give corrosion resistance of sealed coatings and of different anodic coatings, also corrosion tests on various anodic coatings and effect of film thickness on the breakdown voltage. Dielectric constant and breakdown voltage are discussed under the electrical properties of film and finally thermo-properties are considered. 76 references are cited.—ALL. 5807

5.9.4, 6.4.2 Anodizing Aluminum with Sulfamic Acid: Comparison of Sulfuric, Oxalic and Sulfamic Acid Processes. SAKAE TAJIMA, YASUYUKI KIMURA, AND TOSHIRO FUKUSHIMA. *Metal Finishing*, 50, Nos. 10 and 11; 67-71, 65-69 (1952).

The anodizing of 99% aluminum sheet with sulfamic acid was studied. Full details are presented of the experimental conditions. The use of D.C. at a current density of 1 amp/dm² gave satisfactory films in acid above 7.5% concentration at 25 degrees C 1 amp/dm² at 25 degrees C and 7.5% concentration was the optimum current density for good abrasion- and corrosion-resistance in the film. Films formed by AC are rough if formed at 25 degrees C at any concentration. Better AC films may be produced at temperatures above 35 degrees C, but they are still inferior to DC films. Bath temperatures may vary between 25 and 35 degrees C. Steam-sealing of the film produced at 35 degrees C is very effective. The DC film is nearly colorless with higher bath temperature and concentration. The AC film was greenish at higher temperatures. Superimposition of AC on DC was unfavorable to the abrasion-resistance and appearance of the film. Comparison with sulfuric acid and oxalic acid films formed at 25 degrees C and a current density of 1 amp/dm² shows that the thickness of films anodized for 30 minutes was about the same in all cases, but after 45 minutes those from sulfamic acid were thickest. Abrasion-resistance was highest in sulfamic acid films and so was the corrosion-resistance and affinity for dyes. 10 references.—MA. 5820

5.9.4, 6.4.2 The Effects of Steam Sealing on the Character of the Film on Anodized Aluminum (Oxalic Acid Process). T. NAKAYAMA AND M. YAMADA. *Light Metals* (Japan), No. 3, 86-87 (1952) May.

The sealing of anodized aluminum which had been treated with a 3% aqueous solution of oxalic acid was studied. The following results were noted: (1) With the sealing time constant at 20 minutes and the steam pressure variable, the corrosion resistance of the anodic oxide film increases in the ratio 10.6 sec. per pound per square inch, to the increase in steam pressure. (2) With the steam pressure constant at 75 pounds per sq. inch, and the sealing time variable, the corrosion resistance of the film increases in direct proportion to the increase in sealing time. The abrasion resistance decreases slightly.—ALL. 5712

5.9.4 Chromate Protective Coatings. C. W.

OSTRANDER. *Allied Res. Prods., Inc. Product Eng.*, 23, No. 9, 127-129 (1952) Sept. Chromate surface treatments prevent or reduce metal loss caused by corrosion, provide a firm and intimate bond for paint and enhance the surface appearance of metals. These finishes were successfully applied to zinc, cadmium, copper, brass, bronze, magnesium and, more recently, aluminum. Functional properties and application techniques are covered.—INCO. 5728

5.9.4 Phosphoric Acid Treatment Improves Paint Adherence, Corrosion Resistance. W. G. PATTON. *Iron Age*, 170, No. 3, 138-139 (1952) July 17.

Temprite Products Corp. employs the Nielizing process for metal surface conditioning which uses a phosphoric acid base surface conditioner to clean ferrous metals and condition them for painting. Steel parts are cleaned at 180 degrees F in 2-3 minutes. This is followed by a hot water rinse for zinc-coated steel. Uncoated steel parts receive an additional dip in a fixing solution to neutralize metal surface. After drying, the parts are spray-painted and dried in an infrared oven at 275 degrees F. Illustrations.—INCO. 5692

5.11 Design—Influence on Corrosion

5.11 Corrosion—Design It Out! R. B. MEARS. *Can. Metals*, 15, No. 6, 24, 26 (1952) May.

Good designing reduces crevice corrosion and localized corrosion due to stray currents, concentration of ions and high stresses. The selection of proper materials, protective coatings and cathodic protection is discussed.—INCO. 5540

5.11, 3.5.3 Reduction of Wear and Corrosion by Suitable Design and Choice of Materials. O. NIEZOLDI. *Konstruktion*, 4, No. 5, 145-148 (1952) May. *Engrs.' Digest*, 13, No. 8, 245-246 (1952) Aug.

Consideration of design must be combined with correct choice of materials if structural components in engineering are to withstand corrosion and wear. Various examples are cited where a change either in design or a substitute of one material for another, such as a special cast iron in place of a 10% manganese steel, has reduced failures by wear and corrosion. Proper lubrication and correct arrangement of oil channels largely reduces wear of sliding parts. Diagrams.—INCO. 5713

6. MATERIALS OF CONSTRUCTION

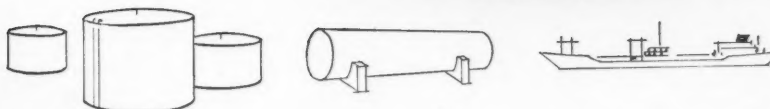
6.2 Ferrous Metals and Alloys

6.2.1 Stainless Steels and Other Ferrous Alloys. W. A. LUCE. *Duriron Co. Ind. and Eng. Chem.*, 44, No. 10, 2346-2359 (1952) Oct.

Methods for conserving critical elements in stainless steel continue to be highlighted. When practicable, the substitution of essentially nickel-free alloys (AISI 400 series) for conventional 18-8 types was suggested. Much basic information was reported on such important topics as corrosion, heat resistance,

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physical and mechanical properties, welding and other fabrication means and typical applications. High-silicon irons, iron-nickel alloys and austenitic manganese steels are included in the review. 287 references.—INCO. 5612

6.2.2, 2.3.6, 3.2.2, 3.7.4

On the Structure of Spheroidal Graphite Cast Iron. A. WITTMOSER. *Giesserei, Tech.-Wiss. Beih. Metallkunde u. Giesseiw.* No. 6-8, 323-334 (1952).

Erroneous assumptions regarding the crystallization mechanism of spheroidal cast iron and their refutation by author's investigations and test data. Difference in structure between spheroidal and lamellar graphite cast irons. Etch test for revealing primary structure. Identification of inclusions developed by etches and characterized by "walls." Investigation into nature of magnesium compounds occurring in these inclusions, such as magnesium oxide, magnesium sulfide, magnesium phosphide, magnesium nitride, magnesium silicide, magnesium carbide and magnesium hydride. Particulars on methods of analysis employed. Results of metallographic studies of inclusions. Application of etchants to detection of sulfides. Reaction of various etchants with inclusions occurring in matrix. Principal nature of inclusions, Mg_3N_2 and Mg_3P_2 determined by analysis. Presence of magnesium sulfide confirmed chemically and metallographically. Problem of occurrence of magnesium oxide. Effect of magnesium treatment of cast iron upon number and kind of nuclei present in it. Influence of "structure" of nuclei on development of graphite structure. Translation obtainable from Henry Brucher, Technical Translations, P. O. Box 157, Altadena, California. 5835

6.2.2

Acids- and Heat-Resisting Properties of Nodular Cast Iron. I. IITAKA AND K. SEKIGUCHI. Repts. Casting Res. Lab., Waseda Univ., Tokyo, No. 3, 17-19 (1952).

Nodular cast iron, commercial cast iron and steel were tested for acid and heat-resisting properties. Nodular iron did not corrode as much as ordinary iron in town water, but corroded rapidly in sodium chloride solution and in sulfuric acid. Results showed that nodular cast iron is superior to cast iron in resistance to oxidation and to growth.—INCO. 5636

6.2.2, 2.3.7, 2.2.7

Investigation of the Mechanical Properties and Sea Water Corrosion Characteristics of Nodular (Ductile) Cast Iron. M. R. GROSS. U. S. Naval Engineering Experiment Station, Report No. 4E (EI) 101717, NS-013-118, June 16, 1952, 14 pp.

Report prepared on the metallurgical properties of nodular cast iron with a brief discussion of the history and the current limitations of this material. Results of tensile, impact, shock, fatigue and corrosion tests performed on as-cast and heat treated material are described. Corrosion tests, including the rotating bar and trough and the rotating disc test, were made in natural sea water at Harbor Island Testing Station. Pitting attack was uniform over the surfaces of the as-cast and heat treated disc of nodular cast iron. The as-cast bar specimens were covered with a layer of corrosion products which resisted the erosive action of the water and shielded the underlying metal from attack. In the

heat treated condition, this protective scale did not resist the erosive action and corrosion-erosion continuously occurred. It was concluded that fully annealed nodular iron is a suitable material for shipboard applications. Tables, illustrations and eight references are included.—INCO. 5599

6.2.2, 1.7.1

Tentative Specifications for Nodular Iron Castings-ASTM Designation: A339-51T. *Foundry*, 80, No. 4, 203-204 (1952) April.

Foundry data sheet covers property specifications for castings made of nodular iron.—INCO. 5493

6.2.3, 3.2.2, 3.7.4

The Stress-Corrosion Cracking of Mild Steels in Nitrate Solution. R. N. PARKINS. *J. Iron Steel Inst.*, 172, 149-162 (1952) Oct. *Metal Ind.*, 81, No. 16, 305 (1952) Oct. 17.

Discusses reason for formation of intergranular macro-cracks in mild steels subject to static stress and corrosive environment of a boiling cadmium-ammonium nitrate solution. Significance of the work is the relationship between carbide distribution in material and its tendency to this type of failure. A further relationship is indicated between lattice distortion of grains and a tendency to stress-corrode. Results indicate that susceptible mild steels have an almost continuous film of distorted ferrite in the grain-boundary region. Suggests theory that this distortion is sufficient to make boundary regions anodic to rest of the grain. Graphs, photomicrographs and tables. 31 references.—BTR. 5684

6.2.4, 3.2.2

Influence of Hydrogen on the Properties of Low-Alloy Steels. K. KREITZ. *Stahl und Eisen*, 72, 1168-1169 (1952) Sept. 11.

Account of experiments on carbon, chromium-molybdenum, 1% nickel, 3.5% nickel and nickel-molybdenum steels. Effects of hydrogen on elongation, yield, impact, reduction of area and tensile properties are given. Steels were tested after varying heat-treatments and in various forms. Relationship between brittleness and flakes is discussed.—INCO. 5626

6.2.5

Cast Alloy Reference Sheet: "FA-20." N. S. MOTT. Cooper Alloy Foundry Co. *Chem. Eng. Progress*, 48, No. 4, 208 (1952) Apr.

Chemical composition range, heat treatment and physical and mechanical properties of 20-29-2-3 chromium-nickel-molybdenum-copper alloy, commonly known as "FA-20." This alloy, primarily developed for resistance to sulfuric acid, also has good corrosion resistance to other chemicals including acids, both organic and inorganic, alkalis and organic materials. Corrosion resistance ratings are given.—INCO. 5703

6.2.5, 3.7.3

How to Weld Stainless Steels. LESTER F. SPENCER. *Welding Engr.*, 37, 45-53 (1952) Oct.

Discussion of above includes welding methods of manual arc, automatic arc, inert gas, gas and atomic-hydrogen. Chrome-nickel and straight-chromium steels are dealt with. Corrosion resistance is mentioned and structure shown. Tables, diagrams, photographs and mi-

crographs of structure. 12 references.—BTR. 5763

6.2.5, 3.7.3

Seventeen Chromium Stainless Replaces 18-8 in Many Weldments. G. E. LINNERT. *Armco Steel Corp. Iron Age*, 169, No. 26, 97-100 (1952) June 26; *ibid.*, 170, No. 1, 128-132 (1952) July 3.

Seventeen chromium steels properly handled show as good corrosion resistance as 18-8 in welded parts. The titanium stabilized 17 chromium grade, Type 430 titanium, is easier to control when the right welding practice is used. Both 430 and 430 titanium show less distortion in welding than 18-8. An austenitic chromium-nickel filler metal is often used to join 17 chromium steels to secure a ductile weld metal in the as-welded condition. For 430 and 430 titanium a 308 (20% chromium-10% nickel) covered electrode or a 308 bare rod is generally selected, although almost any austenitic welding material such as Types 309, 310 or 347 can be applied. Gas torch welding should not be used on Types 430 or 430T grades as grain growth and/or carbon pickup may occur. Shielded welding prevents loss of titanium on 430T. Preheating when using 430 electrodes minimizes the pinhole conditions sometimes encountered. When spot welding cross wire joints a mutual indentation of from 20-30% of the wire diameter is used and proper current from 1-10 cycles is then selected. Fabrication of stainless wire products is discussed. Tables and photographs are included.—INCO. 5731

6.2.5, 4.3.2

Highly Alloyed Stainless Has More Acid Resistance. H. THIELSCH (Welding Res. Council), AND W. E. PRATT (Worthington Corp.). *Iron Age*, 170, No. 2, 135-139 (1952) July 10.

Stainless steels highly alloyed with copper, molybdenum, nickel and chromium show excellent corrosion resistance to a wide range of sulfuric acid concentrations. These alloys can be welded. Tests show that presence of sigma and the copper-rich phases may seriously reduce corrosion resistance to highly active solutions. Control of composition and annealing at 1900-2100 degrees F are recommended. Results on 20% chromium-23% nickel-3% molybdenum-2% copper are tabulated. Photomicrographs, graphs and 11 references are included.—INCO. 5784

6.2.5, 8.9.1, 5.9.4

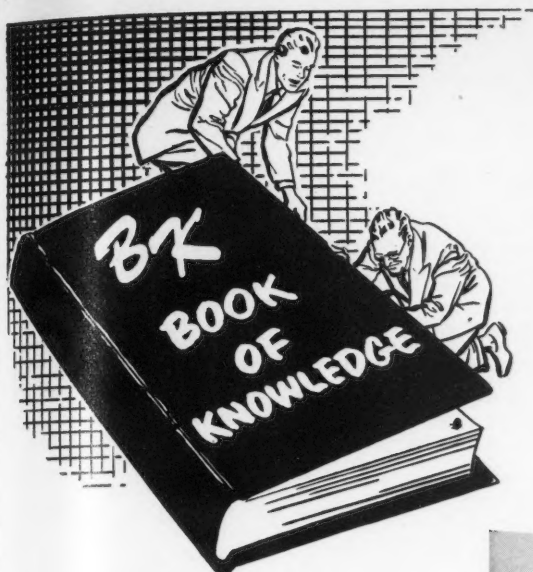
Aircraft Industry Takes a Cautious Attitude. *Metal Progress*, 62, 105-109 (1952) Sept.

Series of brief articles on stainless steels in the aircraft industry: Aircraft Maker Collecting Data on Service Life, A. E. Leach; Polish and Plate to Prevent Development of Rust, J. W. Sweet; and High Corrosion Resistance of Chromized Coatings, T. P. Hoar. Includes table of heat-treating temperatures of wrought chromium-iron alloys.—BTR. 5531

6.2.5

Chromium-Iron Castings. *Metal Progress*, 62, 112-113 (1952) Sept.

Two articles as follows: Substitution of 18-8 Types With Straight Chromium Alloys for Castings, R. J. Wilcox; and 2% Nickel is Good for High Chromium-Iron Alloys, Harvey T. Harrison. Mechanical properties and corrosion resistance are discussed.—BTR. 5530

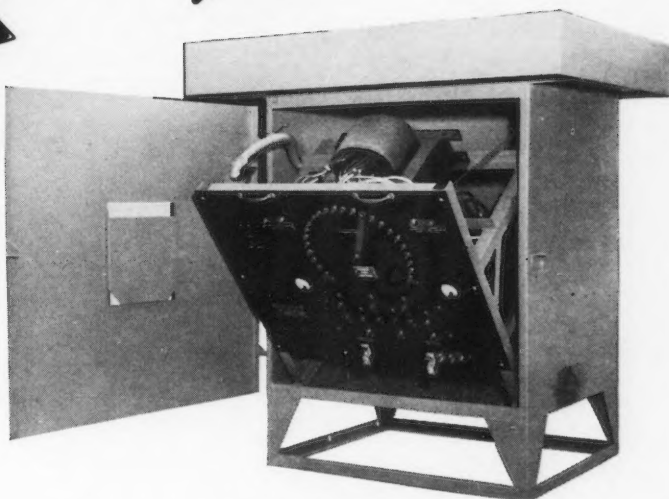


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6.2.5, 3.7.4

Border Cases in the Corrosion of Stainless Steels. L. PIATTI. *Werkstoffe u. Korrosion*, 3, No. 9/10, 325-328 (1952) Sept./Oct.

Nickel-chromium stainless steels generally have given excellent service, but it has happened that unexpected corrosion set in when these materials were used under identical conditions. Slight changes in molecular structure may cause such phenomena. Crystallization of carbides can produce a base metal of low chromium content which is then no longer stable toward some chemicals. Thermal influences, such as welding, can change the molecular structure and decrease corrosion resistance. Eutectoid steels are influenced in their stability through different phase distribution. Occasionally it is possible that corrosion can be caused by interference in the lattice structure. Galvanic corrosion has occurred due to differences in the analytical composition of various parts in the same apparatus. Common methods for testing corrosion are no longer adequate in such cases and other methods must be used. X-ray studies are used to advantage.—INCO. 5681

6.2.5, 3.7.3

Cutting and Welding Stainless Steel. *Petroleum*, 15, 331-332, 334 (1952) Dec.

Discusses above methods which enable, heat, corrosion-resistance and other valuable properties of this metal to be more widely used. Also considers ways in which welded joints should be finished.—BTR. 5674

6.3 Non-ferrous Metals and Alloys—Heavy

6.3.3

A Preliminary Study of the Oxidation and Vapor Pressure of Chromium. E. A. GULBRANSEN AND K. F. ANDREW. *J. Electrochem. Soc.*, 99, 402-406 (1952) Oct.

A report of reactions of chromium with oxygen at 7.6 cm mercury and 700-900 degrees C, as well as high-temperature reactions of chromium in high vacua. Graphs and tables. 22 references.—BTR. 5488

6.3.6

Examination of (Copper) Nails from Submarine Remains of the Greco-Roman Epoch. L. GRAMME AND (MME) A. R. WEILL. *Rev. Met.*, 49, No. 7, 524-530 (1952).

Two nails of the Roman or Greco-Roman epoch, one from Mahdia and one from Anthéor, were examined spectroscopically and by X-rays. The X-ray results of the Anthéor nail appeared misleading and the point was cut off; the section was unexpectedly hard and of blue color. The basis metal of this nail was nearly pure (98.5%) copper-identical with that of the other nail, which had suffered no deterioration—but the point had been completely converted to the sulfide. The nature of the impurities present suggests a Spanish origin of the copper mineral, probably a Spanish sulfide treated in Italy. Gramme and Weill relate this conclusion to the facts known from the history of metallurgy and speculate on the mechanical treatments that the nails had probably received and relate the action of submarine bacteria to the corrosion observed. They conclude that copper immersed in the sea is oxi-

dized when oxygen has access to the metal, becomes sulfurized in the absence of oxygen and remains unattacked or only slightly attacked in the absence of oxygen, sulfates, or other corroding agents. This explains the difference in the state of preservation of the two nails. 11 references.—MA. 5611

6.3.10, 2.4.2

Studies on Anodic Behaviour of Nickel: Part I. G. TRUMPLER AND H. MEYER. *Helv. Chim. Acta*, 35, No. 4, 1304-1310 (1952).

Description of apparatus and technique for these studies. Transition from active condition to stopped condition and back was investigated. A critical potential was found, characteristic of an intermediate electrode state, leading either to passivation or activation and from which for sufficiently small potential-adjustments transition to either end-state slowly ensues. Critical potential is sensitive to hydrogen ion concentration; strongly affected by presence of chlorine ions.—INCO. 5834

6.3.10

Hastelloy Alloy C. E. D. WEISERT. *Haynes Stellite Co. Chem. Eng.*, 59, No. 6, 297-298+ (1952) June.

Forms available, fabrication and applications of Hastelloy C are discussed. Mechanical properties and chemical composition giving nickel content are tabulated. Temperature concentration charts indicating the corrosion resistance of Hastelloy C to over 150 corrosives are given. Illustrations.—INCO. 5803

6.3.10

Hastelloy Alloy D. E. D. WEISERT. *Haynes Stellite Co. Chem. Eng.*, 59, No. 8, 258+ (1952) Aug.

Chart presentation of the corrosion resistance of Hastelloy D (Si 8.5-10.0%, Cu 3.85-4.25%, nickel balance), to a number of corrosives, with data on mechanical properties and applications. Hastelloy D is best known for its exceptional resistance to sulfuric acid of all concentrations and at all temperatures. The alloy has good resistance to many other corrosive media, such as phosphoric acid, organic acids and acid salts.—INCO. 5800

6.3.10, 7.6.1, 8.8.1

Nickel and Nickel-Base Alloys. H. O. TEEPLE. *Ind. and Eng. Chem.*, 44, No. 10, 2325-2338 (1952) Oct.

Current annual review of published references relating to nickel and nickel alloys containing 40% or more of nickel or appreciable quantities of cobalt. Development of new alloys or improvements in present ones and studies of their physical properties; developments in the fabrication and working of these alloys and developments in the applications with reference to the chemical and process industries are covered. 293 references.—INCO. 5783

6.3.10

Examples of Industrial Application based on the Properties and Characteristics of Nickel and Its Alloys. (In Portuguese). HORACE A. HUNNICUTT. ABM (Bol. Assoc. Brasil. Metais), 8, 48-76 (1952) Jan.

Discusses pure or semi-pure nickel, alloys with high and low nickel content and their application with respect to resistance to corrosion, resistance to heat, magnetic and electric effects and im-

provement of their physical and mechanical properties. Includes photographs. 37 references.—BTR. 5618

6.3.10, 3.8.4, 3.2.3

Kinetics of the Formation of Oxide Films on Nickel Foil. W. J. MOORE AND J. K. LEE. *Trans. Faraday Soc.*, 48, Pt. 10, 916-920 (1952) Oct.

Rate of growth of the layer of nickel oxide on nickel was studied from 400-900 degrees C at 10 cm oxygen pressure. The film thickness y increases according to the parabolic law $dy/dt = k/y$, the rate constant k being, in theory, equal to $2D$, where D is the self-diffusion coefficient of nickel in nickel oxide. The entropies and heats can be satisfactorily interpreted in terms of the formation, dissociation and migration of cationic vacancies in the oxide. Tables, graphs and 13 references.—INCO. 5597

6.3.10

Cast Alloy Reference Sheet: Nickel. N. S. MOTT. *Cooper Alloy Foundry Co. Chem. Eng. Prog.*, 48, No. 6, 320 (1952) June.

Discussion of corrosion resistant cast nickel. Applications, composition, machinability, heat treatment, weldability and mechanical and physical properties of nickel are considered. The composition is .2-7% carbon, >99% nickel 1-1.5% silicon, <2% iron. A table showing the ratings of the corrosion resistance of nickel to acids, alkalis, salts, gases, organic materials and various other materials is included.—INCO. 5600

6.3.10, 3.5.9

New High Temperature Alloy. *Materials and Methods*, 36, No. 2, 98-99 (1952) Aug.

New alloy for high temperature service, Hastelloy X, contains 0.15% carbon, 22% chromium, 9% molybdenum, 45% nickel and rest iron. Tests show that the alloy has excellent forming characteristics, good high temperature properties and high resistance to oxidation. A comparison of wrought Hastelloy X and Multimet (N155) is given in table form. Graphs.—INCO. 5582

6.3.10

The Nickel Situation. U. S. Senate, Select Committee on Small Business, Ann. Report 1952 *Metal Finishing*, 50, No. 3, 63-65 (1952) Mar.

Investigation of the critical shortage of nickel. Article describes briefly the consumption, conservation, gray market, and the regulation of prices of nickel. Production and contribution of Inco, Falconbridge Nickel Mines Ltd., Sheritt Gordon Mines Ltd., of Canada, and others are discussed. Tables of statistics are included.—INCO. 5571

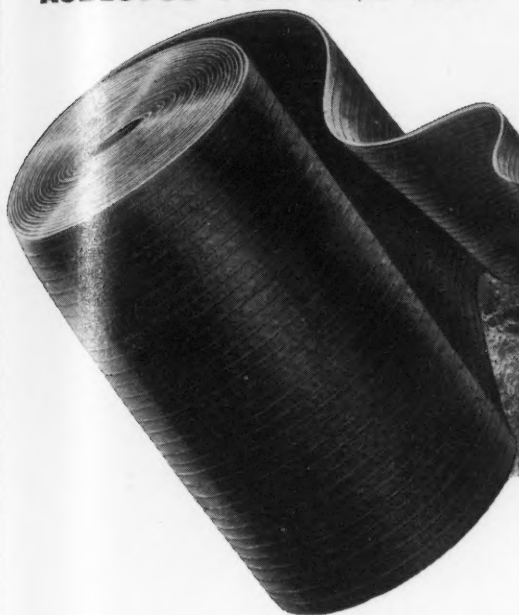
6.3.11

Metallographic Investigation of the Hot Brittleness of Corroded Platinum Apparatus. (In German). G. REINACHER. *Werkstoffe u. Korrosion*, 3, No. 5/6, 192-197 (1952).

Sections from platinum apparatus, damaged by arsenic, bismuth, phosphorus or silicon, were observed microscopically on a hot vacuum stage up to about 850 degrees C. The eutectic melting process giving rise to hot brittleness is reproduced in photomicrographs. The melting of the second phase in the samples containing arsenic, phosphorus or silicon was observed (in agreement with

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the platinum equilibrium diagrams) at 590-598 degrees C, 582 degrees C, and 822-824 degrees C and in the bismuth sample at 712-716 degrees C. The corroded apparatus also shows cold brittleness.—BNF. 5745

6.3.11

The Precious Metals. Materials and Methods, 35, 133, 135 (1952) May.

Data sheets cover gold, silver, platinum, palladium, rhodium, ruthenium, osmium and iridium with respect to physical and mechanical properties, fabrication, corrosion resistance, available forms and uses.—MR. 5579

6.3.13, 6.3.5, 6.3.20, 6.3.16, 6.3.9

Corrosion: Corrosion Resistance of Tantalum, Niobium, Zirconium, Tungsten and Molybdenum Metals is Discussed. MARS G. FONTANA. *Ind. and Eng. Chem.*, 44, No. 7, 71A-72A, 74A (1952) July.

The resistance of tantalum, niobium, zirconium, tungsten, and molybdenum to acids, alkalis and various chemicals decreases approximately in the order named. Tantalum is not attacked by wet or dry halogens or by hydrogen peroxide at the temperatures and concentrations normally encountered in chemical processes. It is also unaffected by hydrochloric acid with or without ferric chloride. Its excellent corrosion resistance, combined with high strength properties, permit the use of very light sections, such as 13-20 mil tubing or sheet, with ensuing economy and high heat-transfer rates. It is attacked, however, by hydrofluoric acid and hot concentrated sulfuric acid, and is not recommended for use with alkalis.

At room temperature, niobium has good resistance to various organic acids and also to mineral acids, except hydrofluoric and hot concentrated sulfuric and hydrochloric acids. Its resistance to acids, including aqua regia and to ferric chloride is better than that of zirconium, but its resistance to caustic is considerably inferior.

When chemically deposited on copper and steel, both tantalum and niobium have been reported to give complete protection against nitric acid for 2-3 months.

Zirconium exhibits good resistance to acids and alkalis except for hydrofluoric acid, concentrated sulfuric acid, hot concentrated hydrochloric acid and aqua regia.—PDA. 5563

6.3.14, 1.5, 5.3.2

Tin and Its Alloys. ROBERT J. NEKERVIS. *Ind. and Eng. Chem.*, 44, 2360-2364 (1952) Oct.

Annual construction-materials review. Previous work reviewed which covers tin alloy electroplating, electroplating and immersion tinning practice, electroplating manufacture, tin-plate production, corrosion resistance of tin-plate containers, corrosion resistance of other tin coatings, hot-dip coating, soft solders and tin-containing materials. 102 references.—BTR. 5711

6.3.15

Final Report on Development of Protective Coatings for Titanium and Titanium Alloys, June 1, 1951-August 31, 1952. JOHN N. REDING, WILLIAM H. COLLNER, MORRIS FEINLEIB, HOWARD T. FRANCIS, AND R. A. LUBKER. Armour Research Foundation, Sept. 16, 1952. 16 pp. Methods for obtaining adherent electro-

deposits on titanium were investigated. Excellent adherence of copper electrodeposits was achieved by subjecting titanium to an anodic etch in a bath based on hydrofluoric acid and ethylene glycol. Operating variables are discussed; they can be adjusted to give electropolished as well as etched surfaces. The bond between plate and basis metal appears to be mechanical. Lesser adherence was obtained by a cathodic treatment in a "zinc strike" based on hydrofluoric acid and ethylene glycol.—NSA. 5742

6.3.15

Advantages of Titanium. *SAE Journal*, 60, 78, 82 (1952) July.

Titanium's big advantage is its high strength/weight ratio. On this basis, titanium can replace aluminum and, below 1,000 degrees F, stainless steel. Many of titanium's other characteristics result from its affinity for oxygen, carbon, and nitrogen, which embrittle. For example: 1) Titanium is costly to produce because air must be excluded and carbon crucibles are out of the question. Furnaces must have a layer of solid titanium between melt and wall. 2) Above about 1,000 degrees F titanium picks up the three contaminants so readily and loses strength so fast that it is useful only as a flame barrier—but very effective in that use. 3) The oxide film that titanium forms at room temperature makes it completely resistant to salt water and appreciably resistant to chlorine and other bleaches. Titanium forges satisfactorily at 1700-1800 degrees F and rolls well at 1400-1600 degrees F—the upper limits being set by oxidation and the lower ones by ductility. The pure-metal grades cold work without damage, with moderate strain hardening. Alloys can be cold worked about 25% between anneals. Commercially pure titanium can be welded with itself by processes that exclude air. Machining requires slow speeds, heavy cuts, positive pressures and very sharp tools because of titanium's tendency to gall and its low thermal conductivity. Oxide scale, if allowed to remain on titanium, will quickly dull the hardest tools. Plentiful as titanium is, it will probably never be as cheap as aluminum or stainless steel because of production costs.—TIME. 5819

6.3.15, 4.6.11

Corrosive Resistance of Titanium. *Westinghouse Engr.*, 12, 114-117 (1952) July.

Titanium possesses an anomalous set of corrosion characteristics. It is an inherently reactive metal. Yet one of its major uses will be established by its ability to resist corrosion. As a self-protecting metal, titanium is best known for its indifference to sea water. In this respect, it has no peer among common engineering materials. It has been subjected at Naval test stations to the corrosive action of sea water for extended periods under all conditions of exposures, with no observable attack. Specimens exposed for three years to salt atmospheres 80 feet from the breakers retained their original lustre. This property naturally suggests many marine applications. To mention but a few, there are lightweight piping systems handling salt water, condenser tubes operating with high water velocities, plumbing fixtures and pump rods and rotor shafts. Relative economics will determine how many of the large-tonnage structural

marine applications titanium can win for itself from stainless steel, cupro-nickel, Monel metal, Hastelloy "C" and other alloys. But, the opportunity for large-scale marine use of titanium is there. The incentive to titanium metallurgists is great.—TIME. 5808

6.3.15, 3.8.3

Passivity of Titanium in Hydrochloric Acid Solutions. DAVID SCHLAIN AND JOSEPH S. SMATKO. *J. Electrochem. Soc.*, 99, No. 10, 417-422 (1952) Oct.

Electrode potential measurements and weight loss corrosion tests indicate that air or low concentrations of certain dissolved metal passivate titanium in hydrochloric acid solutions and that passivity is accompanied by more noble electrode potentials. Air passivates titanium in acid up to 3 normal. Two hundred mg/l Cu⁺⁺ is effective in 10 normal hydrochloric acid and 2 mg Cu⁺⁺ passivates titanium in 5 normal acid. The more noble electrode potentials indicate that a reaction involving oxygen, metal ions, or ions containing oxygen takes place at the passive surface but there is no visible deposit on, or change in, the appearance of the surface except for an occasional slight tarnish. Titanium in contact with small volumes of stagnant 10 normal hydrochloric acid containing 200 mg/l Cu⁺⁺ loses its passivity after a period of time. This time interval seems to be directly proportional to the ratio of solution volume to specimen area and the loss of passivity is attributed to the presence of atomic hydrogen.—NSA. 5794

6.3.15, 5.9.4

Final Report; Development of a Protective Coating for Titanium Alloys; May 18, 1951—February 29, 1952. STANLEY KLIZ, CAESAR KALINOWSKI, AND RALPH WEHRMANN. Fansteel Metallurgical Corp. Mar. 28, 1952, 35 pp.

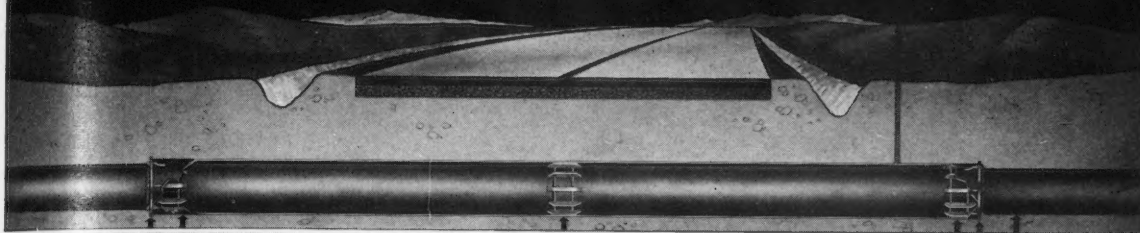
The research program includes preparation of compounds of titanium and silicon, determination of their high-temperature resistance to oxidation, accumulation of x-ray and metallographic data and the preparation and testing of coated specimens. Attempts to prepare TiSi₂, TiSi, TiSi₂ (I), TiSi₂ by heating the elemental powder resulted in the compounding of only I and TiSi₂ (II), and an unknown phase, as determined by x-ray analysis. The silicide powders could be consolidated by powder metallurgy techniques. The oxidation resistance of I was outstanding; no significant change was evident during 1048 hours in air at 1000 degrees C. Theoretical densities of 4.13 ± 0.01 g/cm³ and 4.32 ± 0.01 g/cm³ were computed for I and II, respectively. Coating titanium by pack method which involved submerging the specimens in silicon powder and heating in hydrogen proved unsatisfactory. Coatings obtained by painting titanium strips with a suspension of four parts silicon powder and 1 part glyptal suspended in a mixture of 7 parts Me₂CO and 3 parts alcohol provided some protection.—NSA. 5615

6.3.15, 6.3.20

Corrosion Studies on Titanium and Zirconium Metals; Monthly Report for May 1952. L. B. GOLDEN, W. L. ACHERMAN AND W. MACE. Metals Corrosion Lab., Bureau of Mines, 8 pp. 1952.

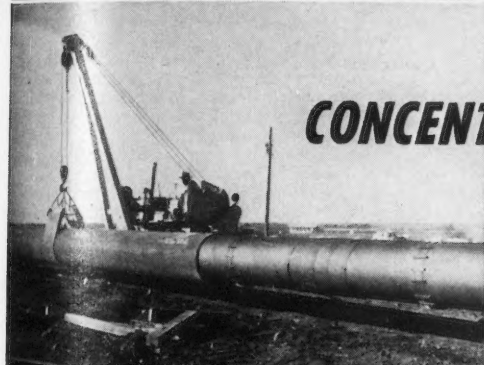
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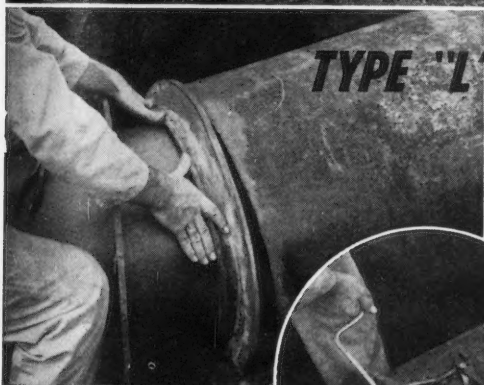
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solutions ranging from 5 to 50% resulted in distinct differences in the relative corrosion rates of arc-melted titanium and metal prepared by powder-metallurgy techniques. An unsuccessful attempt is reported to reduce or eliminate the embrittlement of zirconium caused by solutions of ferric or cupric chlorides by the addition of potassium nitrate. Results of galvanic corrosion studies on titanium and zirconium metals are reported.—NSA. 5609

6.3.15

New At British Industries Fair 1952: Titanium. *Light Metals* (England), 15, 192-194 (1952) June.

Exhibit at British Industries Fair. General discussion of titanium and its various properties, stressing corrosion resistance. Large photographic chart shows the relative resistance to corrosion of titanium and other constructional metals. Also a map showing world distribution of titanium-ore deposits.—BTR. 5587

6.3.15

A Realistic View at Titanium. R. W. PARCEL. Rem-Cru Titanium, Inc. Paper before SAE, Summer Mtg., Atlantic City, June 2, 1952. *SAE J.*, 60, No. 12, 29-32; disc., 32 (1952) Dec.

Advantages, disadvantages, properties, fabrication, marine tests at Kure Beach and applications of titanium are discussed. Titanium lies between iron and aluminum in density, exceeds them in corrosion and flame resistance and compares favorably in yield strength with steel. Titanium was surpassed only by 16% chromium-6% nickel steel in salt-water cavitation tests. It is the only high-strength metal whose endurance limit in salt water approaches the limit in air. Comparison of titanium and stainless steel is given. Illustrations.—INCO. 5676

6.3.15, 5.9.4

Interim Technical Report on Chemical Surface Treatment of Titanium to Watertown Arsenal. H. A. PRAY, PAUL D. MILLER, and R. L. GIBBS. Battelle Memorial Inst. Jan. 31, 1952. 43 pp.

The literature was surveyed for chemical and electrochemical reactions of titanium solutions to obtain useful surface treatments and coatings for titanium. Preliminary tests were performed on the production of oxide coatings. Coatings found by visual, microscopic and electrical examination to have appreciable thickness, continuity and durability were tested for resistance to seizing and galling. Anodic treatments favored oxide formation more than did chemical action. Solutions giving outstanding coatings contained NaOH, NaAlO₂, Na₂O₂, NaClO₂, HBF₄, HCOOH, or NH₄OH as the active bath ingredient; the first four baths furnished the best coatings. Seizure tests employing a loaded-steel-ball abrading surface and a 70-Tsi contact pressure showed that lubricated anodized titanium had good wear properties as compared with bare metal. Coatings from HBF₄ bath were least resistant to galling. Adhesion of olive-drab paint was better on anodized sheets coated in NaOH and NaAlO₂ baths than on bare titanium.—NSA. 5671

6.3.16, 3.2.3, 7.7

A Specific Corrosion Phenomenon on Tungsten Contacts. (In German) ALBERT KEIL. Laboratory for Platinum Smelting,

Pforzheim, Germany. *Werkstoffe u. Korrosion*, 3, No. 7, 263-265 (1952) July.

In the presence of certain phenolic insulating materials and adequate atmospheric moisture, nonconducting organic corrosion products have been observed to form even at room temperature on the tungsten surfaces of electric contacts in sealed instruments. This phenomenon occurs only with tungsten; when exposed to similar conditions, other metals and alloys such as copper or German silver do not undergo any visible changes. The organic corrosion products form on tungsten only after prolonged storage, but can eventually cause operational troubles. Since they are generally water soluble they can be easily removed. Their presence appears to cause no ill effects under normal conditions; however, they must be considered in electrical equipment that is to be transported or stored under tropical conditions, because the rate of the reaction is strongly temperature-dependent. The degree of corrosion is also affected by the nature and concentration of the adhesive in the insulating laminates used. Where specific requirements are imposed on the chemical durability of tungsten contacts, the suitability and compatibility of the insulating materials should be examined by accelerated tests to avoid the possible formation of organic tungsten compounds.—PDA. 5729

6.3.16, 1.6

Tungsten: A Treatise on Its Metallurgy, Properties and Applications. C. J. SMITHELLS. Book, Third Edition. Chapman & Hall Ltd., London, 1952, 326 pp. £3 15s.

In the sixteen years since the second edition there has been considerable development in the manufacture and application. For this present third edition Dr. Smithells, using the same chapter classification as before, has however assumed the role of editor, most of the chapters having been rewritten by specialists on the various topics. Thus, Howell Williams has rewritten the five chapters on manufacture, D. J. Jones has dealt with metallography, D. A. Wright with thermionic emission, the late J. H. G. Moneypenny with tungsten steels, H. W. L. Phillips with non-ferrous alloys, R. W. Rees with hard metals and R. C. Chirside and B. S. Cooper with chemical and spectrographic analysis respectively. There can be no doubt that this book will maintain the leading place in tungsten reference literature which it has held for a quarter of a century.—BNF. 5758

6.3.19, 5.8.2, 2.3.4

A Potentiometric Study of the Interaction of Zinc Ions with Sodium Silicates. J. F. HAZEL, W. M. McNABB, and P. E. MACHEMER. *J. Electrochem. Soc.*, 99, No. 7, 301-307 (1952) July.

Solutions of zinc sulfate, chloride and nitrate were titrated potentiometrically with standard solutions of sodium hydroxide and various sodium silicates. The inflection points found with sodium hydroxide alone were between 75 and 100 percent of the zinc, depending on the nature of the anion; and, when silicates were present, between 100 and 110 percent depending on the silica content. The shifts in the inflection points indicate that zinc hydroxide was absorbed by the silicious precipitates. The results are discussed from the standpoint of the use of silicates as inhibitors to the aqueous corrosion of zinc.—ZDA. 5704

6.3.19

Zinc Metal Finishing Systems. *Prod. Fin.*, 5, No. 12, 83-89 (1952) Dec.

High quality zinc alloy die castings need only a light buffing, after flash removal, to prepare them to receive a decorative finish. This article reviews polishing and buffing procedures and discusses cleaning and preparatory treatments. Details are included on chromate passivation, proprietary black dips, organic coatings and copper-nickel-chromium plating. Dyed finishes are available for producing bright colors on castings intended for interior use, where the tendency of the colors to fade in bright sunlight is no disadvantage.—ZDA. 5738

6.3.21, 2.3.6, 3.7.4

Solution-Body Phenomenon (Lösungskörper) and Anisotropy of Corrosion in Bismuth Single Crystals. (In English). MIKIO YAMAMOTO AND JIRO WATANABE. *J. Japan Inst. Metals*, 16, No. 4, 234 (1952).

A letter. Yamamoto and Watanabe have studied the solution-bodies of trigonal bismuth crystals obtained by etching spherical single crystals of bismuth, which were prepared by a method described elsewhere [Science Repts. Research Insts., Tohoku Imperial Univ., (A), 3, No. 6, 655 (1951)], with 31.6% nitric acid for 1½ hour. This solution-body (Lösungskörper) phenomenon is caused by different rates of corrosion along different crystallographic directions. Yamamoto and Watanabe report that the rates of corrosion along the <111>, <211>, and <101> directions were in the ratio 1.0:1.2:1.4. A cross-section parallel to the (111) plane was hexagonal, whereas those parallel to the (101) and (211) planes were nearly perfect ellipses. 10 references.—MA. 5837

6.3.21, 6.3.15, 6.3.20, 4.3.2

Hafnium Metal—Its Properties and Future. J. L. EVERHART. *Materials and Methods*, 36, No. 5, 95-97 (1952) Nov.

Corrosion resistance of the new metal, hafnium, is still under investigation. The rates of corrosion of hafnium, zirconium and titanium in acid solutions are given in table form. 6 references.—INCO. 5498

6.4 Non-ferrous Metals and Alloys—Light

6.4.1, 5.4.5

Present-Day Position in the Preservation of Light Alloys. G. HOFFMAN. *J. Brit. Shipbuilding Res. Assoc.*, 7, No. 2, 137 (1952); *Hansa*, 88, 1682 (1951).

Paints based on linseed oil have not proved satisfactory for protecting light alloys, since they tend to flake off. Suitable undercoats have a plastic or other synthetic base, while the pigments are usually inorganic zinc or chromium compounds which have an anti-corrosion action similar to that of lead in the case of steel. Inert pigments which improve the adhesive qualities are also used. Top coatings can be of various types, the most suitable being based on oil-modified phthalic resins; these are hard and weather resisting and will stand up to the various cleaning to which they are often subjected. In a modified paint of this type it has been found possible to

reduce the drying time to such an extent that a second coat can be applied half an hour after the first. Chlorinated rubber paints have been found excellent where chemical stability is required. Considerable care is, however, required in their application and in practice they are employed only where their properties warrant this amount of trouble. The usual method of applying paint on board ships is by brushing, but considerable savings in both material and time can be effected by spraying and it is considered that this may well become more widespread at sea.—RPI. 5509

6.4.2

The Electrochemical Behaviour of Aluminium in Buffered and Alkaline Solutions of Potassium Ferricyanide and in Sodium Hydroxide. J. V. PETROCELLI. *J. Electrochem Soc.*, 99, No. 12, 513-519 (1952) Dec.

A study has been made of the reactivity and polarization characteristics of pure aluminum in buffered and alkaline solutions of potassium ferricyanide and in sodium hydroxide. Electrode potentials, weight loss data and polarization curves are presented. It is shown that the reaction of aluminum with these electrolytes may be interpreted from an electrochemical point of view. The analysis of the polarization behavior is based on the theory of the "mixed potential."—ALL. 5689

6.4.2, 3.2.2, 3.5.8

Aluminium Corrosion Prevention: Part 3. Stress Injuries. GEORGE W. ORTON. *Light Metal Age*, 10, No. 7/8, 20 (1952) Aug.

In some alloys when a mechanical stress and a corroding medium act together and at the same time, corrosion will take place along certain defined paths, as along grain boundaries or slip planes. The corroding medium need not be highly corrosive. Intergranular cracks will occur at places which show internal or external stress. In aluminum alloys stress corrosion occurs only when a highly supersaturated solid solution is present. Pure aluminum and low-alloyed aluminum therefore show no tendency to stress corrosion, nor do aluminum-silicon casting alloys. Copper-bearing alloys show some susceptibility but if properly heat treated and not subjected to elevated temperatures in use or if coated with commercially pure aluminum or an anodic aluminum alloy, they are regarded as stress corrosion resistant. However, stress corrosion may endanger the good mechanical properties and resistance to corrosion of aluminum-magnesium alloys. The susceptibility toward stress corrosion increases with the amount of magnesium. A magnesium content of over six percent is inadvisable. Stress corrosion does not occur with a magnesium content of three percent. In five, seven and nine percent magnesium alloys, the resistance toward corrosion is largely dependent on the heat treatment used. They are resistant to stress corrosion in the homogeneous state. Stress corrosion is connected with a definite precipitation phenomenon which appears in the case of alloys with supersaturated solid solutions. When this occurs the possibility of stress corrosion results.—ALL. 5708

6.4.2, 5.8.2

Aluminium Corrosion Prevention: Part 4. Temperature Importance. GEORGE W. ORTON. *Light Metal Age*, 10, No. 9/10,

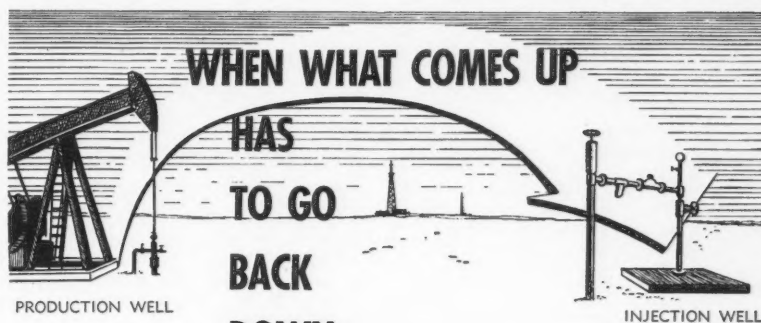
17 (1952) Oct.

A reduction of stress-corrosion in alloys in a supersaturated state is made possible by alloying additions and by certain heat treatments such as air quenching and heterogenizing at a temperature just below the boundary line. Protective coatings may also give favorable results. In the aluminum-magnesium-zinc system the solution heating temperature is important in determining the stress-corrosion behavior. In the range of 400-425 degrees F the susceptibility to stress corrosion of vanadium-free alloys is greatly increased with increasing heat treating temperatures. By the addition of vanadium and chromium, the transition range occurs at higher temperatures. A metal may be readily corroded when first attacked by a corroding agent but after sufficient exposure the rate of attack may become nil.

Also, a metal may be corroded by a dilute acid and yet suffer little attack in its concentrated form. Most cases of passivity appear to be attributable to a protective film although it may not be an oxide film. The corrosion inhibitors which have been found most useful in connection with aluminum alloys are silicates, chromates, dichromates and soluble oils. Silicates and chromates inhibit the corrosive action of carbonates; chromates and dichromates are used to combat atmospheric moisture and friction corrosion. Inhibitors and passivators are generally oxidizing compounds. They isolate the metal from its environment and limit the diffusion of moisture and oxygen.—ALL. 5707

6.4.2

Aluminium Corrosion Prevention: Part 2. Causes and Results of Electro-Chemi-



... Here's How To Cut Cost and End Trouble In Your Salt Water Disposal Wells!

Whether your salt water problem is re-pressuring or simple disposal, you can reduce overhead costs sharply by eliminating replacement expense due to corrosion losses. Have your new or existing tubing string lined with Tube-Kote's TK-43, the amazingly tough corrosion-proof lining. TK-43 gives your pipe years of life in either injection or production wells.

No other type of corrosion control gives you such complete protection: tubing lined with TK-43 is not damaged by brine, acids, alkalis, or crude; its sleek surface resists abrasion and ends flow-velocity erosion; its insulating properties stop electrolytic action caused by contact of dissimilar metals.

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P. O. Box 20037 • Houston 25, Texas

cal Action Described. G. W. ORTON. *Light Metal Age*, 10, No. 5/6, 18-20 (1952) June.

Electrical potential between points on an aluminum surface may be caused by a multitude of conditions, including: Impurities, grain boundaries, differential grain size, orientation of grains, differential thermal treatments, local scratches and abrasions, differences in shape, differential strain, surface roughness, differential pre-exposure to air or oxygen, differential concentration of corroding solution, differential aeration, differential heating, differential illumination, differential agitation, contact with dissimilar metals and externally applied potential. Metallographic considerations, such as the form of an alloying constituent also influence corrosion. Dissimilar metal contacts are of particular importance. Oxygen depolarization is probably of widest importance. The influence of oxygen, film repair, the electrolyte, secondary corrosion products and the formation of an impervious film are also discussed.—ALL. 5716

6.4.2, 5.3.2, 5.9.4

Hard Aluminum Finishes Resist Wear and Abrasion. R. V. VANDEN BERG. *Iron Age*, 170, No. 18, 81-83 (1952) Oct. 30.

Shows that harder, thicker and denser anodic surface coatings which have better resistance to wear and abrasion are now available for aluminum. The combination may replace heavier metals for such things as gears, slides, pinions, pistons and many aircraft applications. Reports that other materials such as chromium, tin, brass and lead have also been coated onto aluminum to give outstanding characteristics. Photographs.—BTR. 5810

6.4.2, 8.1.2

Corrugated Aluminum for General Building in Israel. *Light Metals* (England) 15, No. 172, 244-245 (1952) July.

Over 15,000 corrugated aluminum huts have been built in Israel during the last eighteen months to accommodate the recent influx of immigrants into the country. These buildings have proven more weatherproof and durable, less costly and more quickly constructed than those of wooden structure. Each hut, housing one family, requires 30 sheets or 600 sq. ft. of corrugated aluminum. Aluminum has also been used extensively in promoting the industrial and agricultural growth of the country. Frequent use of aluminum is found in roofing, irrigation pipes, sanitary installations, household equipment, farm buildings, schools and even temporary places of worship. "Palalim," Israel's leading aluminum ware manufacturers, now manufacture kitchen and cooking utensils for local use and export.—ALL. 5569

6.4.2, 2.2.7, 1.7.2

The Resistance of Light Alloys to Marine Corrosion. A. GUILHAUDIS. *Rev. Aluminium* (France) 29, No. 186, 187, 188; 85-91, 127-133, 175-179 (1952) March, April, May.

The author believes that one of the most essential factors in determining the corrosion resistance of any aluminum alloy is the establishment of corrosion testing stations in the natural atmospheres and that while laboratory alternating immersion tests in saline solutions are beneficial to a certain extent, no such tests can be as exacting as those

carried out near the sea. A description is given of the marine corrosion test stations at Salinde-Giraud and St-Jean-de-Luz, established by the Service des Recherches et Essais Physiques de Chambéry of the Pechiney Company. The author reviews the results of tests carried out on non-protected alloys of aluminum including aluminum-manganese, aluminum-magnesium, aluminum-magnesium-silicon and aluminum-copper-magnesium, these alloys having been submitted to spray, permanent immersion and alternating immersion tests. The aluminum-magnesium (3 to 5 percent) alloy is most resistant to marine corrosion. The alloy A-G5 with a chemical content as follows: iron 0.16%, silicon 0.13%, copper 0.035%, manganese 0.44% and magnesium 5.15%, aged at 400 degrees C, was found to be the most corrosion resistant of all those tested. Cold working of the alloy had scarcely any effect on its corrosion resistance. Where the copper content of aluminum alloy is over 2 percent it radically lowers the corrosion resistance. The aluminum-magnesium-silicon series has approximately the same resistance as the aluminum-magnesium series, although it generally tends to be somewhat lower. When aged at high temperatures, it is more corrodible than when aged at room temperatures. The aluminum-copper-magnesium alloys do not have a high corrosion resistance to salt water. Graphs indicate the rate and amount of corrosion to these alloys exposed to permanent immersion and to spray. Two samples were immersed, one having been partially passed through a blowtorch and the other not. The part of the piece which received heat from the torch was corroded, whereas, the remaining portion was relatively free of corrosion. It was also found that the underside of many sheets was corroded while the upper side remained undamaged. The rain had washed away traces of the salt on the metal. In the last part of the article the author reviews the aluminum-zinc-magnesium alloys, the aluminum-zinc-magnesium-copper alloys and the casting alloys. Protection of any alloy against corrosion is possible by cladding it with pure metal or an aluminum-manganese alloy. However, care must be taken when treating the aluminum-copper alloys in this way for the copper has a tendency to diffuse through the cladding, and corrosion results.—ALL. 5561

6.4.2, 5.9.4

Some Notes on Hard-Coating Aluminium. H. E. HORN. *Metal Finishing*, 50, No. 6, 110-112 (1952) June.

A hard oxide coating may be applied to the surface of aluminum by immersing the part to be coated as the anode in an electrolytic bath. The coating develops in such a way that it builds half inwardly and half outwardly from the original surface. A series of tests, utilizing the Profilometer, showed that the hard-coated surface had about the same surface smoothness as the bare metal. A coating produced on a specimen of 61S-T6 aluminum showed a hardness of 530 VPN (Vicker's Pyramid Number) using a 200 gram weight and imbedding the test diamond into the coating for 30 seconds. This degree of hardness is equivalent to 51 Rockwell-C and approximately 250,000 psi tensile strength. The coating was not marred or scratched by repeated strokes with a file. The oxide layer is inert to corrosion elements. Hard coated

test panels did not show any sign of corrosion under salt spray tests for over 600 hours of exposure. Aluminum parts are not warped or distorted in the hard coating process. Aluminum should not be heat treated following the application of the hard coating. All tempering should be completed prior to the coating process as extreme heats will affect the wearing qualities of the coating. The following alloys have been found satisfactory for hard coating: Wrought alloys—2S, 3S, 52S, 61S, 75S and all alclads; sand-cast alloys—43, 214, F214, 220, 355, 356, 645; die-cast alloys—43, 214 and 218.—ALL. 5555

6.4.2, 3.7.2

Study of the Age-Hardenable Aluminium Alloys Containing Beryllium. Y. MISHIMA. *Light Metals* (Japan), 5, No. 3, 29-34 (1952) May.

The effect of small additions of beryllium on the age-hardenability of the commercial aluminum alloys was investigated, as well as the increased stress corrosion resistance of the aluminum-zinc-magnesium alloys by similar additions. On the aluminum-copper system it was found that 0.3 percent beryllium could increase the strength of a 4 percent copper alloy to that of duralumin. The effect was not so marked in the aluminum-copper-magnesium system. The corrosion resistance of the alloys aluminum-copper, aluminum-copper-magnesium and aluminum-zinc-magnesium was only slightly improved by the addition of beryllium. Nine binary aluminum alloys of the zinc, silver, magnesium, tin, silicon, manganese, nickel, antimony and cadmium systems were examined, having had 0.5 percent beryllium and 0.5 percent magnesium additions made. None of these were found to have a Vickers hardness of over 100 in the fully aged condition, with the exception of the aluminum-zinc-magnesium-beryllium system. In the aluminum-magnesium-silicon, aluminum-zinc-copper, aluminum-copper-manganese and aluminum-magnesium-iron systems 2 percent beryllium was added. The second and third of these systems were found to reach the strength of duralumin with room temperature aging. The aluminum-magnesium-copper-manganese-beryllium system increased most in strength with addition of beryllium.—ALL. 5533

6.4.2, 5.9.1, 1.1

Aluminium-Surface Treatment and Colouring. W. W. G. HUBNER. *Ciba Rev.* (Switzerland). No. 92, 3294-3324 (1952) June.

This review of the subject is divided into four separate papers covering the specific subjects: 1) The Colouring of Metals—Historical Aspects, 2) Extraction and Manufacture of Aluminium, 3) The Surface Treatment of Aluminium and 4) The Colouring of Aluminium. Three excellent and comprehensive flow-sheets are given: 1) Production and manufacture of aluminium (raw materials, manufacturing processes, industries, semi-finished and finished goods), 2) Aluminium alloy applications in various industries, and 3) Various stages of aluminium surface treatment (mechanical, chemical or electrolytic pretreatment, anodic oxidation and coloring). A list of current processes in use for anodic surface treatment is presented in table form giving the following details: Process, bath solution, concentration, temperature (degrees C), duration (min.).

voltage, current (amp/sq dm), thickness of film in microns, appearance, properties, applications and notes. A bibliography is provided covering the four papers.—ALL. 5501

6.4.2, 3.7.4, 3.2.2

Intercrystalline Fracture in Aluminum-Zinc Alloys. E. C. W. PERRYMAN. *Compt. Rend.*, 235, No. 16, 884-886 (1952) Oct. 20.

To confirm a previous hypothesis (Cf. NACE Abstract Card No. 299, classified 6.4.2, 3.5.8, 3.7.4), stating that in the aluminum-zinc alloys the aluminum solid solution stable at the temperature of aging is responsible for the delayed intercrystalline fracture, two specimens containing 13.4 percent zinc were homogenized for 3 hours at 450 degrees C, quenched in water and aged, one for 10 days at room temperature and the other for 284 days at 125 degrees C (when equilibrium was reached). The structure of this specimen consisted of a zinc-rich precipitate in a solid solution of 5 percent zinc. The specimen was then stress corrosion tested in 3 percent salt fog. After two days the specimen aged at room temperature showed intercrystalline corrosion but there was no cracking in the second specimen after 57 days. It appeared evident that the tendency to cracking and intercrystalline corrosion depends on the existence of a new solid solution at the grain boundary during aging and that the fracture is caused by relative movement between the grains.—ALL. 5685

6.6 Non-Metallic Materials

6.6.4

Carbon and Graphite. J. P. OLIVER. *National Carbon Co. Chem. Eng.*, 59, No. 9, 276- (1952) Sept.

Corrosion resistance of carbon and graphite to various acids, alkalis, organic compounds and other chemicals is given in chart form. Additional data on physical properties, available forms of carbon and graphite and applications are included.—INCO. 5730

6.6.4, 4.7

Dynamic Corrosion of Graphite by Liquid Bismuth. W. J. HALLETT AND T. A. COULTAS. *North American Aviation, Inc. Rep.*, 22, 1952, 21 pp.

No corrosion or mass transfer of graphite by bismuth was observed when the liquid metal was circulated by means of thermal convection in an all-graphite system. A calculated linear velocity of approximately 7 in/sec was maintained for a period of 279 hours at a maximum temperature of 1400 degrees C and a minimum temperature of 875 degrees C. No metallographic evidence of solution of graphite in bismuth was found and measurement of the inside diameter of the tubes before and after operation showed no change of dimension. No indication of penetration of the graphite by bismuth was found.—NSA. 5503

6.6.6, 6.7.2

Ceramics and Metallurgy. H. W. GREENWOOD. *Machinery Lloyd* (Overseas Ed.), 24, 89-91 (1952) Mar. 1.

Recent applications of ceramics in aiding resistance of metals to corrosion, erosion and high temperatures, in the forms of ceramic bodies, coatings, or ceramic-metal combinations.—MR. 5613



➤ Recaulking expansion and structural joints on concrete roof deck at one of the large Long Island Lighting Company power plants. All previous caulking compounds proved unsatisfactory and were removed and replaced with DEL.

➤ Applying 1/8" thick coating of DEL Synthetic Rubber Caulking Compound (Thiokol Type) to inside of a condenser water box. Long Island Lighting Co. pumps sea water into the condenser from Jamaica Bay at temperatures from 32 to 76° F. Photo from cover of Feb., 1954, CORROSION published by National Association of Corrosion Engineers.

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is a paste which cures without shrinking
to permanent, flexible solid rubber.

OUTSTANDING FEATURES

- When used as a protective coating can be applied at any desired film thickness in one coat
- Adheres to metal, masonry, wood, glass, etc.
- Cold process vulcanization—no heat required
- Resists water, sun, gasoline, oils, dilute acids and alkalis
- Non-shrinking
- Permanent elasticity
- Unaffected by most solvents
- Easy application
- Applied by knife, trowel or caulking gun
- May be sandpapered or cut with sharp tools
- Can be coated over with paints or protective coatings
- Does not become brittle in cold weather; remains flexible at temperatures as low as 65° F.
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- Good aging characteristics
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TYPICAL USES

- Sealing around pipes coming through walls, tanks or equipment
- Filling cracks in concrete floors
- Sealing concrete ducts, conduits and pipes at joints
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- Sealing cracks in storage tanks
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- May be troweled on surfaces and used as a protective coating
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6.6.8

Reinforced Polyester Plastics. R. B. SEYMOUR AND R. H. STEINER. *Atlas Mineral Prods. Co. Chem. Eng.*, 59, No. 12, 278+ (1952) Dec.

Chart data presentation of the corrosion resistance of reinforced polyester resins to a number of corrosives, including acids, alkalis and organic reagents, with mechanical and physical properties, forms available and applications.—INCO. 5764

6.6.8

Unplasticized Polyvinyl Chloride. J. L. HUSCHER. *Am. Agile Corp. Chem. Eng.*, 59, No. 11, 264+ (1952) Nov.

Corrosion resistance of unplasticized polyvinyl chloride to a number of corrosives, such as acids, alkalis and organic chemicals, with data on the physical properties and methods of fabrication. Charts and tables.—INCO. 5506

6.6.11, 8.9.5

Decay in Wood-Built Boats. M. G. DUFF. *Ship & Boat Builder*, 5, 246 (1952); *J. Brit. Shipbuilding Res. Assoc.*, 7, No. 3, 194 (1952).

Fungal decay and other forms of deterioration caused by insect attack and chemical action are discussed. The prevention of fungus attack by suitable design, by storing under satisfactory conditions when out of the water, etc., are considered. Fungal decay originating in the external skin is very rare, but vessels that are stored ashore for some months should have the paint film made good within 7-10 days of hauling out. There is an excellent case for the limited use of fungicides. Prevention of general decay associated with the aging of timber depends primarily on good maintenance. Chemical decay of timber has not been found to be a serious menace. Damage due to dry-wood borers is rare and instances of attack may be dealt with as they occur. Marine borers, however, appear to be responsible for as much damage below water as all other forms of timber decay. The first requirement is an unbroken paint film and only points where there is difficulty in maintaining this require other treatment.—RPI. 5521

6.7 Duplex Materials

6.7.2

Chrome Carbide Provides High Corrosion Resistance. J. D. KENNEDY. *General Electric Co. Steel*, 131, No. 5, 92-95 (1952) Aug. 4.

Grade 608 chromium carbide, first of the new Series 600 cemented chromium carbides, is available. It has high resistance to both corrosion and erosion and good abrasion resistance. Made by the powder metallurgy process it is light in weight, is non-magnetic and has resistance to high-temperature oxidation. The metal is composed of 83% chromium carbide, 2% tungsten carbide and 15% nickel. A table gives the physical properties.—INCO. 5551

6.7.2

Moly Based Metal Ceramic Designed for High Temperature Use. *Iron Age*, 170, 114 (1952) Oct. 16.

Briefly describes above and lists its physical and mechanical properties. Known as D-1922 and developed by P. R. Mallory and Co., it is a hybrid incorporating molybdenum disilicide and suitable ce-

ramic components. Potential uses are surveyed.—BTR. 5629

6.7.3, 7.7

Applications of Copper-Clad Aluminum. *Metallurgia*, 46, No. 273, 39-40 (1952) July.

Copper-clad aluminum is available as sheet, circles, strip, busbars, etc. Thickness varies from 40 swg to 5/16-in. One or both sides may be copper-clad, the thickness of the aluminum in the standard grades being 70, 80 or 90 percent of the total. Care must always be exercised to avoid having the aluminum bared, the propensity toward corrosion being extreme. Trademarked "Cupal," the material is used in the manufacture of reflectors and heat exchangers and domestic coal-fired hot water boilers. The copper surfaces can be soldered as easily as copper alone. The electrical field finds the greatest potential use for the material, its use in conductor systems is increasing steadily. By the use of single clad Cupal washers or shims, suitably protected at the cut edges, the only copper-to-aluminum joint is within the Cupal and away from any corrosive agents.—ALL. 5632

6.7.3, 3.7.3, 8.9.2

For Automobile Radiators: A New Aluminum Brazing Sheet. *Modern Metals*, 8, 52, 54 (1952) July.

Developed by Aluminum Co. of America, No. XA30 brazing sheet is a composite of three alloys—a 3S alloy core is coated on one side with a low-melting-point brazing alloy, and on the other side with a corrosion resistant Alclad alloy. Solution of the corrosion problem. Diagram.—MR. 5698

7. EQUIPMENT

7.1 Engines, Bearings and Turbines

7.1, 3.5.3

Friction—Main Cause of Engine Wear. J. F. KUNC, JR., D. S. McARTHUR, AND L. E. MOODY. *Standard Oil Dev. Co. Paper before SAE, Summer Mtg., Atlantic City*, June 1-6, 1952. *Petrol. Proc.*, 7, No. 9, 1263-1266 (1952) Sept.

It appears that friction along with some mild abrasion is the principal cause of automobile engine wear. Low temperature corrosive wear does not seem to play an important part in wearing engines in average field service. It is felt that efforts should be directed toward reducing frictional wear in engines as a means of solving the engine wear problems. Tables and illustrations.—INCO. 5524

7.1

New Bearing Made of Any Material, Lubricated with Any Fluid. R. M. HIGGINS. *Allis-Chalmers Mfg. Co. Iron Age*, 170, No. 11, 158-160 (1952) Sept. 11.

Fluid piston type bearing for pumps doesn't need to be made of bearing materials, nor lubricated with oil or grease. But horsepower requirements are high. Its primary use is on pumps that have to be lubricated by the liquid being pumped. This bearing circumvents the penalty of low viscosity bearing fluids. It practically eliminates the existence of and minimizes the harmful effects of fretting corrosion. Diagrams.—INCO. 5622

7.1, 5.8.2, 8.9.4

Control of Corrosion in Locomotive Diesel Engines. A. C. MENGEL. *Am. Locomotive Co. Paper before 3rd R. R. Corrosion Conf., Harbor Testing Station of Inco, Wrightsville Beach*, May 6-8, 1952. *Ry. Mech. and Elec. Engr.*, 126, No. 6, 65-68 (1952) June.

Elimination of scale and embrittlement in steam locomotive operations consists of four preventive measures: Proper maintenance of SO_2 - CO_2 ratio; maintenance of proper ratio of $CaNO_3$ to alkalinity in feedwater; use of steel of lower tensile strength in boiler construction, so that stresses at grain boundaries are lower and adoption of the all-welded, stress-relieved boiler. Early corrosion problems in Diesel-electric locomotives and methods used by the Am. Locomotive Co. to combat cylinder-liner corrosion are considered. Reducing the velocity of water by mechanical means and treating water with chromates reduces corrosion. Protection of metal surfaces by chromate inhibitors, using iron as an example, is explained and chromate concentrations are recommended. If corrosion occurs with the use of chromates, it is due to a lapse in chromate control. A disadvantage in using chromates is their toxicity. Illustrations show appearance of corroded diesel-engine cylinder liners.—INCO. 5596

7.1

Aviation Spark Plug Fouling—Its Cause and Control. Part I. Its Control by Tricresyl Phosphate. Part II. Its Major Cause, Metallic Lead. V. E. YUST (Shell Oil Co.) AND E. A. DROEGEMUELLER (Pratt & Whitney Aircraft). Paper before SAE, Ann. Mtg., Detroit, Jan. 17, 1952. *SAE Journal*, 60; Nos. 5 & 6; 65-73, 37-40 (1952) May, June.

Part I. Tests on tetraethyl lead content of fuel showed that TCP (tricresyl phosphate) used as a supplementary to ethylene dibromide (EDB) lead scavenger reduces spark plug fouling by lessening the lead content of spark plug deposits which seems to be responsible for fouling. Comparison of isomers full-scale single-cylinder tests, mechanism of TCP, general performance characteristics, evaluation in a full-scale engine with Ni-resist guides, lubricating oil properties and current status of TCP—EDB scavenger are discussed. TCP has no effect on preignition ratings using either nickel or platinum electrode-type plug.

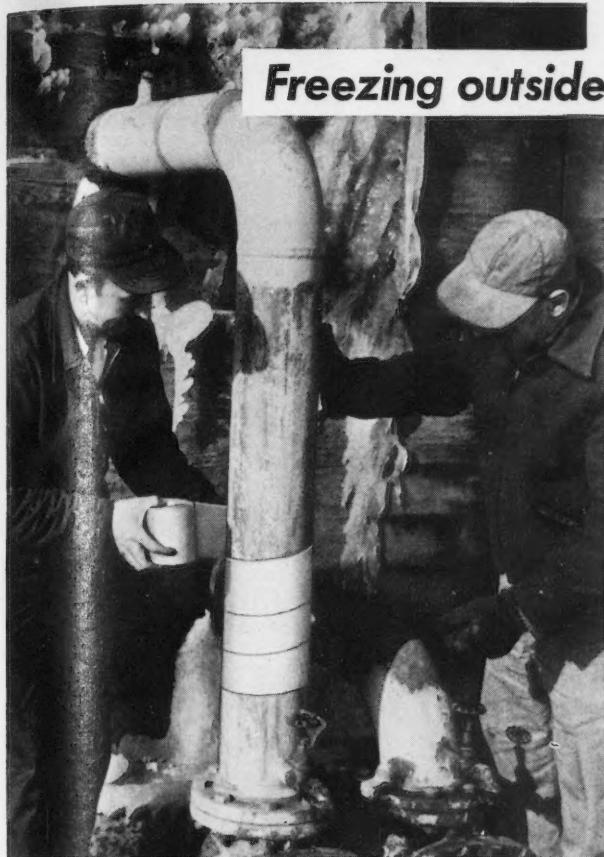
Part II. Discusses laboratory and field investigation of spark plug fouling, correlation between laboratory and field plugs, combustion chamber deposits, analysis of laboratory test plug deposits, correlation of lead with fouling and the mechanism of metallic lead formation. Graphs, tables, discussion, illustrations.—INCO. 5809

7.1, 5.8.2, 3.6.6

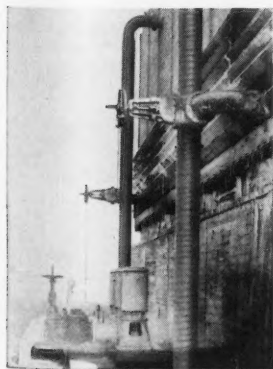
Corrosion of Ball Bearings. *Steel*, 131, 84, 87 (1952) July 28.

The Naval Research Laboratory of the Office of Naval Research, Washington, reports that a proper corrosion inhibitor can reduce or sometimes even prevent the corrosion of brass retainer ball bearings. This study was prompted by difficulties experienced by ball bearing manufacturers, military laboratories and maintenance depots from corrosion of steel balls and races in brass-retaining ball bearings during storage. Corrosion in the form of fine specks was observed on steel parts of these bearings after storage in rooms controlled at 70 to 80

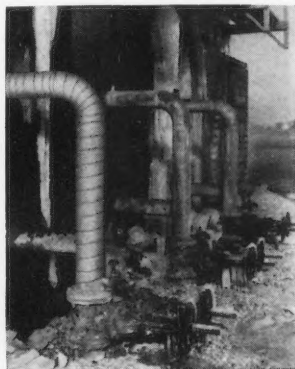
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Cold weather . . . hot pipe . . . and still the job is easy! Polyken protective tape coating goes on fast and smooth, bonds tight to the pipe and to itself on the overlap with its special adhesive.



In service nine months with no sign of wear—and two men wrapped these 35-foot 12-inch pipes in less than four hours.



See the difference between the pipe at left protected with Polyken tape and rust and corrosion on pipes at right.

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BEATS

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Compressor Station No. 10 is a key operation of Michigan-Wisconsin Pipe Line Company.

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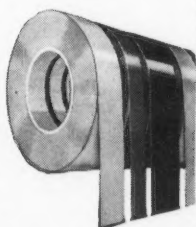
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degrees F and 30 to 40 percent relative humidity. To solve the problem, it was first necessary to duplicate this corrosion and analyze the corrosion product. To duplicate in a short time conditions that developed after relatively long storage periods, special test specimens and conditions were employed. In laboratory tests, a special lubricant with a high concentration of rust inhibitor in the diester was used. To increase the amount of corrosion produced under laboratory conditions, specimens were exposed to temperatures of 136 degrees F at a relative humidity of 36 percent. Medium to heavy corrosion resulted in periods varying from 7 to 21 days. Observing the effect of humidity on corrosion of brass in contact with steel, a series of tests were made in desiccators over anhydrous calcium chloride. None of the specification lubricants caused corrosion on a steel-brass couple in the absence of water vapor, even at 136 degrees F for 30 days. Corrosion encountered in these tests was shown to be electrolytic in nature and probably accelerated by small quantities of acids formed by oxidation or hydrolysis of the lubricant. It was then necessary to develop methods or lubricating compositions that could be used to alleviate this action. By combining acid neutralizing qualities of an amine with rust inhibiting qualities of an organic acid and thus developing amine-acid complexes, satisfactory corrosion and rust inhibiting compositions were evolved.—EL. 5754

7.1, 5.8.2

Ball Bearing Greases for Motors at Extreme Temperatures. F. J. OLIVER. *Elec. Mfg.*, 50, No. 6, 90-95+ (1952) Dec.

Work of the Air Force and the Navy is correlated with the results of independent investigations on ball bearing greases used to lubricate various equipment. Most satisfactory answer to the wide temperature range problem was found in synthetic lubricants of the organic ester type. Acids developing in a grease having a poor resistance to oxidation are often the cause of bearing corrosion. The Naval Research Lab. studied the problem of electrolytic corrosion of bearings with brass retainers. By combining the acid neutralizing qualities of an amine with the rust inhibiting qualities of an organic acid, satisfactory corrosion and rust inhibiting compositions were evolved. Another answer to the electrolytic corrosion problem is to use phenolic laminate retainers if the temperature is not too high. Military specifications for ball bearing lubricants are given. Tables, graphs and 15 references.—INCO. 5717

7.1, 6.4.1, 8.9.4

Concerning Some Applications of Light Alloys for Bearings in Railway Equipment. (In Italian). L. PAGLIALUNGA. *Alluminio*, 21, 43-47 (1952) Jan.

Experimental results in comparison with other bearing metals show better high-temperature wear and fatigue resistance.—MR. 5724

7.2 Valves, Pipes and Meters

7.2

Schedule 5 Pipe Conserves Stainless Steel. *Power*, 96, No. 7, 188 (1952) July. New light-walled Schedule 5 stainless

steel pipe conserves critical alloys. When compared with heavier pipe, such as the well-known Schedule 40, this new pipe provides 2 or 3 times the pipe footage per pound of stainless steel. Made from the standard stainless analyses as set up by the Am. Iron & Steel Inst., the pipe offers full corrosion resistance in every respect.—INCO. 5658

7.2, 8.4.3

Drill Pipe Rejects Show Good Service. H. G. TEXTER. *National Supply Co. Petroleum Engr.*, 24, No. 13, B-78+ (1952) Dec.

Discussion of a study to determine the sort or depth of mill defects which would result in failures of drill pipes. Steps taken to delay corrosion fatigue were so effective that out of 28 failures there were only three definite cases of corrosion fatigue. A conclusion of the study is that ordinary types of mill defects—seams, pits, scores, etc., are negligible factors in causing drill pipe failures. Not one of the fatal defects resulted in a fishing job. All showed up as washed out cracks. Photographs.—INCO. 5790

7.3 Pumps, Compressors, Propellers and Impellers

7.3, 5.8.2, 4.6.6

Reducing Corrosion. *Oil Gas J.*, 51, 97-98 (1952) June 9.

Corrosion of shafts and columns in deep-well vertical-turbine pumps, a major problem in water production. The selection of inhibitors was limited since the water was used for domestic and industrial purposes. The agent selected was one of the glassy molecularly dehydrated sodium phosphates. Diagram.—INCO. 5718

7.6 Unit Process Equipment

7.6.4

Having Boiler Handhole Gasket Trouble? *Power Eng.*, 56, No. 5, 85 (1952) May.

Answers to questionnaires as to what the utilities were doing about boiler-gasket failures did not indicate any clear-cut solution to the problem. Failures were reported by about one-half of the filled gasket users. The jackets were made of copper, Monel and mild and stainless steel. Copper and stainless steel jackets appeared to give better service. Plain Monel gaskets had about the same record as the filled gaskets. Some companies attributed attack to electrolytic corrosion resulting from the contact of the boiler steel with dissimilar gasket metal. In some cases acid cleaning was blamed.—INCO. 5826

7.6.4, 3.5.8

Caustic Cracking in Boilers: Prevention by Chemical Methods. C. D. WEIR AND P. HAMER. *Chemistry and Industry*, No. 43, 1040-1049 (1952) Oct. 25.

Paper examines the basic soundness of the sulfate treatment as regards laboratory experiments and operational experience and attempts an evaluation of alternative and chemical treatments, particularly the use of sodium nitrate. Schroeder detector, a device used as a means of detecting the embrittling tendencies of boiler waters and testing the

efficacy of chemical inhibitors, is described. Effects of sodium sulfate, organic materials and sodium nitrate on cracking and co-ordinated phosphate treatment are discussed. Caustic cracking of boiler steel depends on a high concentration of caustic soda in contact with metal under a relatively high tensile stress. Graphs and references.—INCO. 5827

7.7 Electrical—Telephone and Radio

7.7, 6.4.2

All-Aluminum Conductors for Overhead Line Construction. *Elec. World*, 137, No. 26, 90 (1952) June 30; *ibid*, 138, No. 2, 126-129 (1952) July 14.

The Detroit Edison Co. has prepared specifications for aluminum conductors for its distribution manual and this is a summary of the standard practice which can serve as a practical guide for any electric utility. Four sizes of wire are being furnished in aluminum—No. 4 Aluminum Triplex for use in place of No. 6 Triplex copper wire; No. 1/0 Aluminum 4/16-inch Neoprene wp to be used in place of No. 2 Neoprene or braid-covered copper for new extensions. No. 3/0 Aluminum, 5/64 Neoprene will be system-wide in place of No. 1/0 wpx or wp for new extensions. Use of aluminum secondary where large quantities of copper services exist should be avoided. 350,000 cir mil Aluminum wp will be used in place of No. 4/0 copper for lines at primary voltage. In addition to these sizes of covered all-aluminum conductors, 477,000 cir mil bare ACSR will be used on certain 24/40-kilovolt lines of large capacity. For easy substitution, both copper and aluminum will be available in equivalent sizes. Aluminum should be kept separated from bare or old weather-proof copper. To secure a good lasting electrical contact at splices or taps on aluminum, the aluminum wire should be coated with a film of corrosion inhibiting grease and then brushed with a wire brush or emery cloth. Where splices are made with preformed splices, the covered aluminum conductor must be skinned, coated with inhibiting grease and cleaned before the preformed splice is applied. Where preformed deadened ties are applied, the conductor must be skinned. In a recent survey of 52 power companies in the United States the following statistical summaries were developed: Half of the tonnage of all-aluminum wire and cable in use today is in customer service. One-quarter is used for transmission and primary distribution circuits. Secondary circuits account for 4½ percent and the remaining percentage is used in miscellaneous application. Stranded all-aluminum conductors receive preference over solid, for both primary and secondary application. In aluminum-to-copper joints an oxidation inhibitor is usually applied to all joints, either before or after burning-in the conductor. Some sort of tape—friction, cellulose or plastic is used on the joints. Nearly three-quarters of the companies use aluminum cable in any location, but one-quarter avoid its use in industrial or sea-coast areas. Asked for a general classification of results to date 22 replied "generally satisfactory," 3 "adequate," and 1 "poor."—ALL. 5558

7.7

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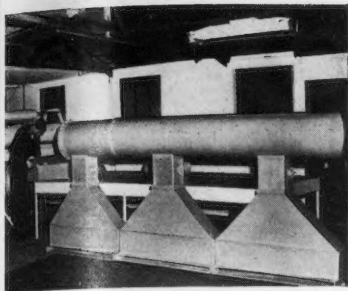
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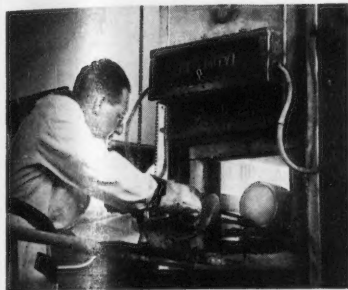
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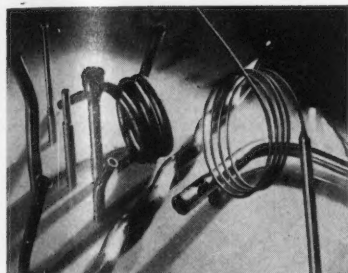
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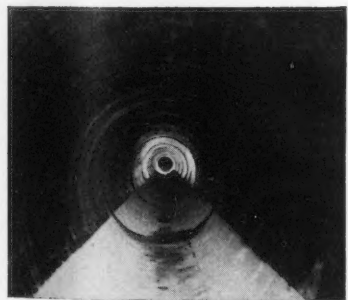
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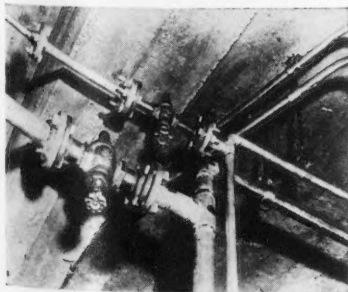
High temperature ceramics



Small gauge alloy tubing



Linings and coatings for pipe



Corrosion-resistant plumbing

Metal Progress, 61, No. 6, 65-70 (1952) June.

To satisfy certain requirements 16 types of inorganic finishes and many kinds of organic systems have been adopted. The parts manufactured are relatively small, but are produced in sufficient quantities to justify the use of fully automatic platers for zinc, nickel, copper-nickel and gold, as well as individual barrel plating sections for zinc, copper-tin, nickel, silver and gold. In making the number plate for the dial telephone, the copper-nickel automatic plater is used to coat ordinary cold rolled mild steel so that a white ceramic enamel can be applied in one operation. Undercoats for enamel, barrel plating arrangements, Sherardizing, de-ionizing for pure water, organic enamels and acid handling are considered. Photographs are included.—INCO. 5573

7.7, 4.2.7

Study of Navy Radio Receivers in a Tropical Climate. K. G. WILLIAMS AND C. T. LEMPKE. U. S. Naval Research Lab., Report No. 3935, 24 pp., 1952.

Weathering tests on radio receivers made up of various materials and coated with different varnishes (some containing fungicides), plastic and cellulosic materials are reported. Moisture absorption and not fungus growth, was found to be the main cause of component breakdown.—RPI. 5813

7.7, 6.4.2

The Chemical Behaviour of Aluminum Overhead Lines. W. V. ZWEHL. *Aluminum* (Germany), 28, No. 12, 455-456 (1952) Dec.

Opinions vary as to whether it is preferable to use ACSR or Aldrey cables under poor atmospheric conditions. Although some cables of ACSR and Aldrey installed close to the sea have retained perfect serviceability for some decades, it is considered advisable to observe a safe distance of 10 km from the coast. It can be assumed, however, that cables which have shown good chemical resistance for twenty years or more, will remain in good order for another 20 years. Reports from England, France, Italy and the United States are included, all of which give favorable reports on the corrosion resistance of aluminum cable.—ALL. 5816

7.7, 6.4.2

Making Connections in Underground Aluminum Cable. J. ROGOFF AND I. MATTHYSSE. *Elec. World*, 138, No. 2, 129-132 (1952) July 14.

Aluminum underground cable connectors are installed by hydraulic compression tools; the tubular compression sockets for the aluminum cable are also aluminum. Corrosion is one of the minor problems as the joints are carefully taped. Surface oxide causes high resistance contacts. A joint compound will best overcome this, by breaking down the oxide film. Metallic zinc particles in one such compound form current-carrying bridges across the contact surfaces. As a result of time and temperature influences on a compression joint, the metal may "relax," causing it to creep under pressure. The creep rate for copper is greater than that for aluminum, under pressure. In order to enlarge the areas on contact, between connector and cable and between the strands of cable, thereby decreasing possibilities of creep, indented or crimped connections of stranded alu-

minum conductors should be large in area and the indent should be deeper. A secondary network system is designed to clear cable faults by the operation of Limiters, unless the fault burns itself clear. The compression connectors for these installations must be about 50 percent longer and installed with one or more additional indentations, than in the case of copper. In a case where aluminum and copper cables are joined, the aluminum compression splice connector can be varied to provide multiple connections between aluminum and copper cables. Adapters may also be used for joining the two cables. These consist of tubular aluminum compression sockets which receive the aluminum cable, joined to a plug which may be inserted into a copper connector. The "reducer" is used for joining cable end to end. An aluminum and copper compression socket is joined together at the factory. In connecting primary cable the effects of the connector compound on the quality of insulation are of importance, for they may cause swelling of rubber insulation. A new compound, recently developed, has zinc particles suspended in a polyisobutylene vehicle. Heat cycle tests are necessary at lower rates (100 to 125 degrees C), since primary cables cannot be subjected to temperatures as high as on secondary cables. As a result of this, shorter contact lengths and fewer indentations on primary connectors are possible.—ALL. 5753

7.7

Deterioration of Transformer Oil. Part II—Influence of Transformer Constructional Materials. L. MASSEY. *J. Inst. Petroleum*, 38, 281-297 (1952).

Transformer constructional materials influence the rate of oil deterioration. Experiments to determine this influence, both on an accelerated basis and under conditions approximating to transformer practice, are described. Copper is shown to be much more active than any other similar material and the reasons for its variable behavior have been investigated. Under certain conditions impregnating varnishes are involved in sludge production and lead to erratic oil performance. The exact mechanism involved is not fully understood, but it is believed to be associated with the formation of oil-soluble copper salts in the interior of coils by interaction between the windings and unpolymerized varnish. The migration of copper from a coil interior to the surrounding oil is proved. Thin films of varnish used to protect exposed metal surfaces are shown to be inert towards oil and to form effective barriers isolating the metal from contact with the oil.—RPI. 5832

7.8 Wires and Cables (non-electrical)

7.8, 8.4.1

Corrosion of Colliery Winding Ropes. O. P. HANSOM. *Wire Prodn.*, 1, No. 8, 6 (1952) July.

The main causes of failure in wire ropes are considered and the steps which can be taken to increase their lives described. Records in Ruhr collieries over many years show that galvanized ropes last 20-25 percent longer than non-galvanized ropes, even though the former are often used only for the more arduous service conditions. U. S. records of rope breakage contain very few ex-

amples of galvanized ropes failing in this way. The article also mentions briefly the relative advantages of hot dipped and electrogalvanized wires.—ZDA.

7.8, 8.8.5

Wire Production in Brazil. R. G. WALKER. *Wire Production*, 1, No. 7, 16-18 (1952) June.

Describes the works of the Companhia Siderurgica Belgo-Mineira which started operations in 1920 at Sabara, in Minas Geraes, Brazil. Four blast furnaces and four Martin furnaces are installed for iron and steel making and the rolling mill and drawing equipment are briefly described. Wire galvanizing is done on a single line carrying 40 wires. The grease-drawn wire is annealed in a tunnel-type furnace at 750 degrees to 800 degrees C, hydrochloric acid pickled and then dipped in zinc at 450 degrees C. All the wire is asbestos wiped, but is given either a dull finish involving no water quench, a satin finish when water quenched 8 to 10 ft. from the wipe, or a silver finish when quenched 6 inches from the wipe. Zinc consumption averages 8% on the 50 tons of wire galvanized each day.—ZDA. 5804

7.10 Other

7.10

How to Choose Spring Materials. (Concluded). M. GERARD FANGEMAN. *Materials & Methods*, 35, 112-116 (1952) May.

Explains how the cost and performance of a spring depend on the material used and how each material meets particular stress, accuracy, corrosion-resistance and shock-resistance requirements. Table gives mechanical and physical properties, heat treatment and uses of twelve common ferrous and nonferrous spring materials.—BTR. 5656

7.10

The Spring Steels, Their Development, Properties and Applications. (In German). SEPP AMMARELLER. *Stahl und Eisen*, 72, 475-488; disc., 488-489 (1952) April 24.

Gives results of scaling tests and alternating-stress tests. Effects of surface finish, corrosion and cross section of specimen were studied. Describes manufacture, heat treatment and applications of the springs. Graphs, diagrams and tables, 30 references.—BTR. 5657

7.10

Air Brake Corrosion Problems. C. E. MACFARLANE. *Westinghouse Air Brake Co. Ry. Mech. & Elec. Engr.*, 126, No. 7, 72-76 (1952) July.

Corrosion of air brake equipment is discussed. Among the materials used for fabricating the equipment are aluminum, cast iron, brass, zinc, die castings, steel plastics, aluminum alloys and stainless steel. The protection methods discussed are dip painting using zinc chromate oxide primer, protective coatings and use of oil containing corrosion inhibitors. Accelerated laboratory tests such as water spray or immersion tests, judging results by appearance, weight or sometimes tensile tests are used. Outdoor exposure tests on panels follow the preliminary tests. Small steel springs, once nickel plated, are now cadmium or zinc plated. Photographs.—INCO 5699

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8. INDUSTRIES

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8.1.4, 6.4.2

The Effect of Excreta on Aluminum and its Alloys. R. BUTLER AND E. W. SKERREY. *Light Metals*, 15, 261-266 (1952) Aug.

Effects of human and animal excreta on aluminum and its alloys is being investigated in a sewage disposal plant, a factory latrine, and a cattle barn. Results obtained after exposure up to 3½ years indicate that aluminum and its alloys are suitable for use in each of these environments and that NS4 (BA.21) is the most generally suitable alloy. Test panel photographs and tables.—BTR.

5334

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